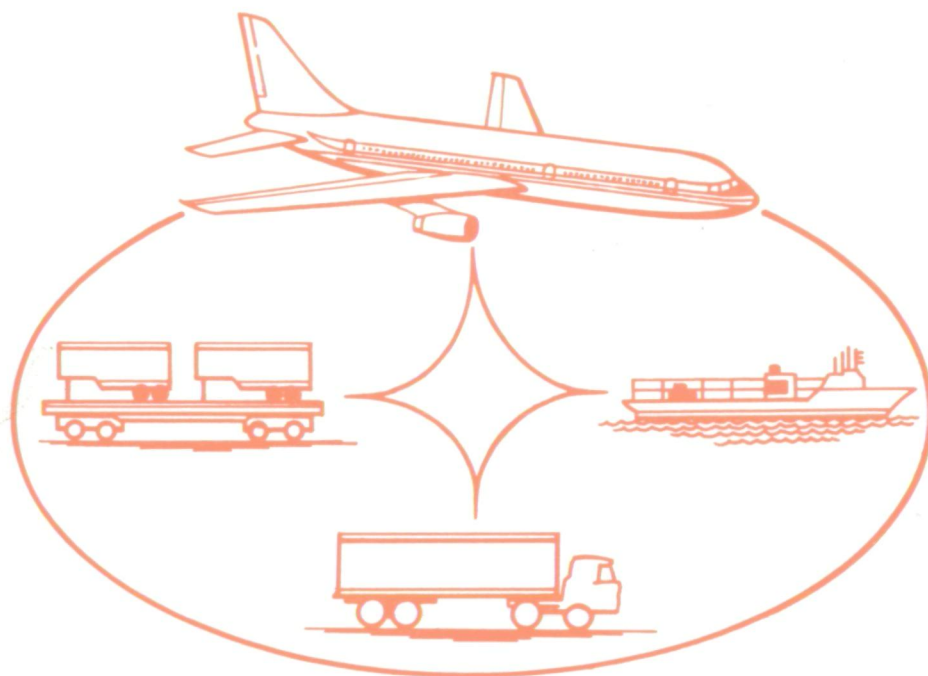


AIR CARGO: AN INTEGRATED SYSTEMS VIEW



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SEPTEMBER, 1978

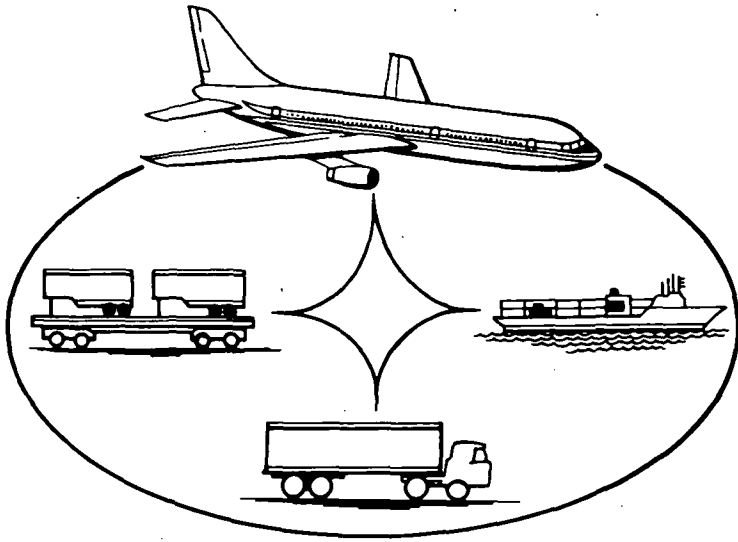
NASA

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ODU
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AIR CARGO: AN INTEGRATED SYSTEMS VIEW



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1978 SUMMER FACULTY FELLOWSHIP PROGRAM IN ENGINEERING SYSTEMS DESIGN

SEPTEMBER, 1978

NASA-LANGLEY RESEARCH CENTER
AMERICAN SOCIETY FOR ENGINEERING EDUCATION
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PREFACE

This report presents the reader with a view of the nation's air cargo system of the 1990's. We believe that the system described is the best obtainable through an evolutionary development from today's system. In other words, no drastic changes in technological, economic, social, or political trends are envisioned.

The study which produced this report was conducted by a group of 20 scholars representing eleven disciplines who were gathered at Langley Research Center under the auspices of the NASA-ASEE Summer Faculty Fellowship Program for 11 weeks during the summer of 1978. Their task, as assigned by the National Aeronautics and Space Administration (NASA), was to examine the nation's air cargo system and suggest ways in which it can be encouraged to make a more vigorous, effective, and productive contribution to the nation's transportation needs.

While the topic for the 1978 NASA-ASEE Summer Faculty Fellowship Program was selected by Old Dominion University and NASA to be one of current interest to NASA, neither ODU nor NASA otherwise limited or directed the study. It was intended to be an independent view, representing the conclusions of a broadly selected group of professionally qualified but independent outsiders, who themselves determined the scope and nature of their study.

This group did not begin its work in a vacuum of data; on the contrary, abundant sources of information were made easily available. Salient among these sources were two studies very recently completed for NASA. They were conducted under the title, Cargo/Logistics Airlift Systems Study (CLASS). The CLASS studies collected and analyzed extensive amounts of data from the transportation community. One was performed by Lockheed-Georgia Company and one by the McDonnell Douglas Corporation. Completed in the spring of 1978, they provided a very strong and timely basis on which this study could be grounded. Another reason the summer of 1978 was especially timely for a study of air cargo was the recent deregulation by Congress of much of the air freight industry.

After coming together early in the summer, this group struggled with the problem of setting for itself goals which were reachable but which would nonetheless assure that a real contribution to NASA planning was made. The decision was made that an examination of some of the problems in the infrastructure of the Air Cargo system might yield the desired results. The components of the infrastructure which seemed to need the most attention were listed as:

1. The Regulator Framework
2. The Ground Support System
3. The Nature of the Network
4. Government Involvement
5. Societal Impacts

The first four on this list evolved into chapters of this report. The fifth was an area of concentrated study, the results of which appear as parts of each chapter.

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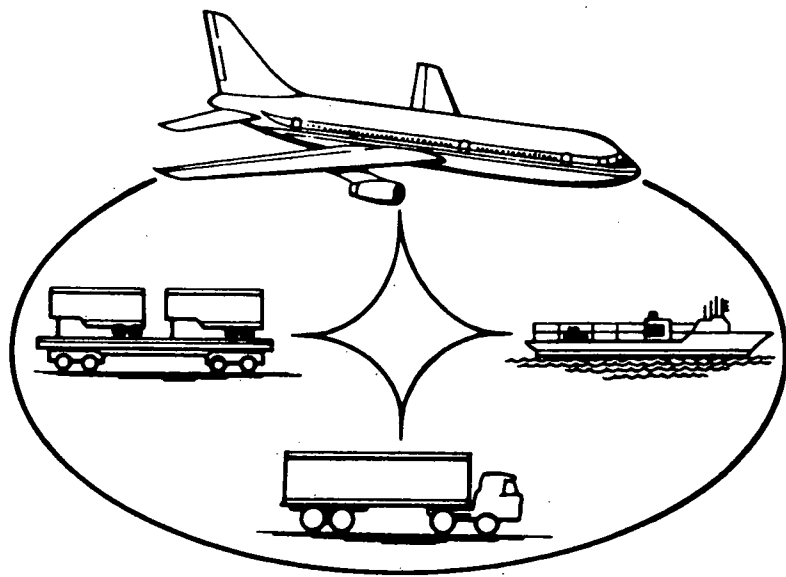
The authors of this report, having come together and worked in concert for a relatively short period of time, hope that the vigor of their effort and the richness of the interdisciplinary environment have helped to produce a valuable piece of work in spite of the nemesis of time. We also fully realize, and wish to take note of, the valuable assistance provided by those outside their ranks. Prominent among these are the speakers who are listed in Appendix. They made, without exception, valuable contributions to our work. Special mention should be made of Mr. Allen Whitehead of NASA who acted as our primary technical advisor. Allen originally set the tone of our study and maintained close contact with us throughout. His high level of technical competence, broad knowledge of the air cargo industry and general enthusiasm made our work much easier and more pleasant.

Credit must also be given to Mr. Frank Owens of the Personnel-Training & Educational Services Branch, Langley Research Center. Frank seemed to be able to anticipate our every need and created an environment which was most conducive to productive research.

Our special thanks go to our administrative staff. The typing of this report, which was done principally over the short span of the final two weeks, was efficiently accomplished by Beverly Dorton, Barbara Kehoe, and Carol Privette. The credit for all illustrations and other drawings in this report goes to Kirt Babuder, our illustrator. The quality of his work speaks for itself.

Michael Davis provided computer support on a daily basis. He proved to be a most innovative programmer and his work made the computer an invaluable resource. Carol Privette, in addition to typing a large portion of the report acted as librarian in our local library. The ease with which we obtained reference material is testimony to her efficiency.

It is obvious that the material in this report has been collected from many sources. We hope proper recognition has been made in all cases. The reader is urged to assign credit to sources where it is due but to realize that error in fact or judgement should be assigned to the authors only.



INTRODUCTION

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INTRODUCTION

The air cargo system is like a healthy duck which everyone expects to change into a swan. However, despite our expectations, the duck persists in "failing"-it remains a duck. Does this "failure" stem from internal "tragic flaws", a harsh environment, or our expectations? The answer to this question is -- yes!

Air freight is a growing industry, but it has not grown in the manner or at the rate forecast. Hence, we perennially perceive it as failing, and the failure to grow in the expected way is caused by an interlocking set of internal and external factors; factors which the actors in the system control and other factors which they do not.

Our report is both analytical and prescriptive. We analyze the national air cargo system and prescribe how it should appear in 1990 in order to operate successfully through 2015; that is, through one equipment cycle.

Chapters one and two deal with elements of the system which are largely under the control of the major actors; the airlines and the aircraft manufacturers. These chapters deal with aircraft, networks, facilities, and procedures. Chapter three considers the regulations which govern the movement of air freight; what happens here is not totally under the control of the system actors. Chapter four addresses the larger public policy interests which must be served by the kind of system we are proposing -- the air cargo integrated system (ACIS). Our emphasis throughout shall be upon the concept "integrated".

At many points in the report, the possible social, economic, political, and environment impacts of the system are considered. Impacts are summarized in a special section of our report which bears that title.

The last major section of the report contains our summary and the team's recommendations. These recommendations range from statements on optional aircraft size for the system, through institutional changes which must be effected to allow new technology to function effectively, to specifying some areas of future research with regard to air cargo systems. These recommendations are the "bottom line" of our report.

To understand our recommendations is one thing, to fully grasp the team's rationale for offering them is quite another. As proponents of a systems approach, we believe that a comprehensive overview of an entity is a prerequisite for understanding that entity.

The system we have been studying is quite complex and richly jointed. We do not believe that a comprehensive picture can be obtained without reading most of the text. Therefore, to know why we have offered a particular recommendation, the reader may have to go rather deeply into the report.

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The report which follows is supported fully by all team members. Throughout the summer, we rigorously pursued the goal of producing a report organized around one theme. In order to reach this goal, the communication of ideas had to be undertaken. Design proposals, objectives, and conclusions were scrutinized and evaluated by teams, and in many instances by the entire group. Some ideas were filtered out and others interjected by this process.

Early on in the project, assumptions and objectives were fixed. The systems design approach when applied with ultimate thoroughness would lead to an interminable discussion of an infinitude of possible futures. This is due to the "overlook nothing" nature of the approach. Therefore, in order to make a beginning, certain assumptions were made early in the design process which constrained our conception of the environment in which the future air cargo system would exist. It is important that the reader know what boundary conditions were established before analyzing the report. Our assumptions were:

1. The increase in surface traffic over the next 15 years will result in a degradation of service making air shipment a more attractive option.
2. Air cargo needs will be 2-3 times present levels contributing to saturation of the present system by 1988.
3. Expansion of existing airports due to lack of available land will be difficult.
4. All future aircraft and airport construction will have to meet present environmental constraints.
5. The U.S. Government will continue to support R and T to improve aircraft and ground support.
6. Standardized intermodal containers will become more frequent in use.
7. Advances in technology will offset rise in fuel cost so that direct operating costs will not rise merely as a result of rise in fuel cost.
8. Peaceful co-existence will continue among the major powers and there will be no radical shifts in spheres of influence.
9. World economic climate will not undergo major fluctuation.
10. The nations will be unable to satisfy its military airlift need completely with military resources. There will be strong governmental support for sharing civil - military capacity.

In addition to knowing what assumptions were made, it is also important to understand what objectives our design team set for the air cargo integrated system. Not only did we make our objective explicit, to the best of our ability, but we spent considerable time establishing an ordered relationship between these objectives.

In ordering our objectives, we employed a technique called "interpretive structural modeling", making use of software developed at the University of Dayton.

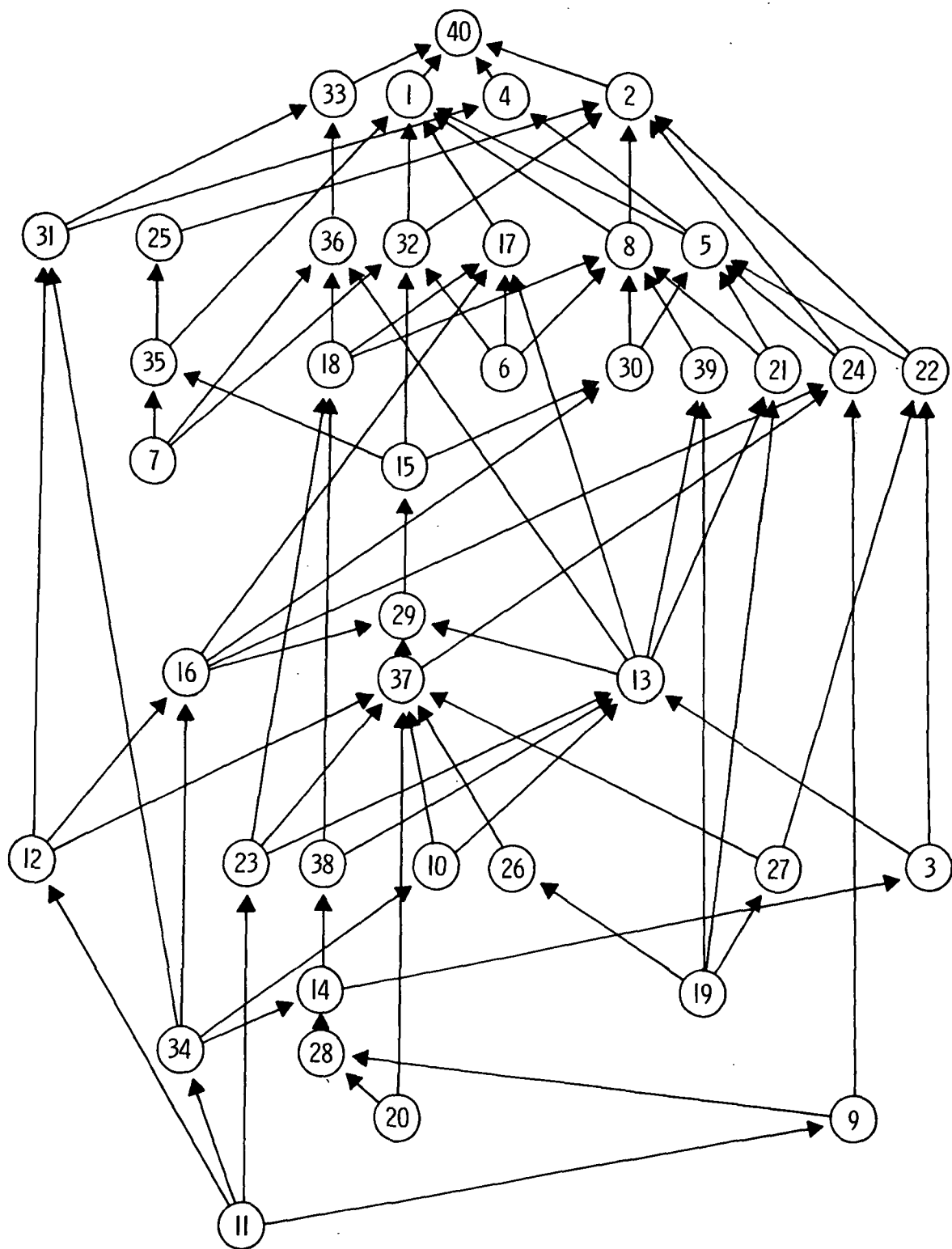
From an initial unordered list of 56 objectives, the structure shown in Figure 1 was developed. When our ordering and editing procedure was completed, only forty objectives remained. The directional relationship indicated by the arrow can be literally expressed as, the achievement of objective A (at the tail of the arrow) contributes to the achievement of objective B (at the head

of the arrow) in an essential way.

The discussion accompanying the development of this objective structure brought about considerable clarification of term definitions and helped formulate common concepts in the minds of all involved. Though the product of this exercise is not offered as a major contribution of the design effort, the process of its development was most helpful to us.

LIST OF OBJECTIVES FOR ACIS

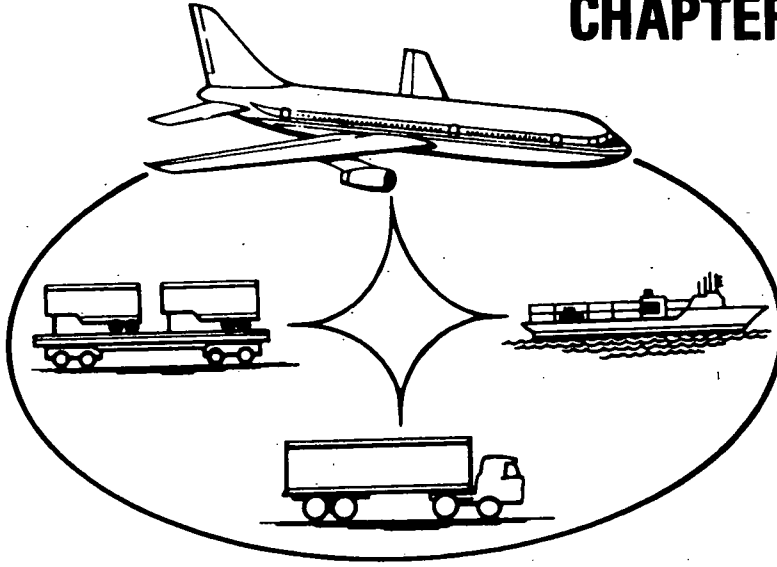
- 1 - To meet civilian air cargo needs
- 2 - To meet military air cargo needs
- 3 - To develop an effective ground support system that will accomodate advanced aircraft
- 4 - To minimize detrimental environmental impacts
- 5 - To minimize energy consumption of oil based fuels
- 6 - To have cooperative labor relations
- 7 - To identify air cargo markets
- 8 - To provide for terminal security
- 9 - To establish an appropriate international legal framework
- 10 - To establish an appropriate domestic legal framework
- 11 - To build elite support for an advanced system
- 12 - To build mass support for advanced systems
- 13 - To integrate all modes of cargo transportation
- 14 - To develop effective unitization
- 15 - To integrate appropriate feeder aircraft
- 16 - To integrate appropriate trunk aircraft
- 17 - To be capable of meeting national emergency needs
- 18 - To provide adequate terminal capacity for projected cargo volumes
- 19 - To establish minimal service criteria
- 20 - To integrate freight forwarders
- 21 - To eliminate terminal delays
- 22 - To minimize damage
- 23 - To provide adequate access links for other modes
- 24 - To provide for simultaneous civilian/military use of terminals, aircraft, and crews.
- 25 - To provide sufficient reserve aircraft for military emergencies
- 26 - To provide secure storage for secret cargos
- 27 - To provide safe storage for hazardous materials
- 28 - To standardize weight, sizes, and shapes of cargo units as far as possible
- 29 - To improve profitability for air carriers
- 30 - To give door-to-door service
- 31 - To maintain U.S. superiority in scientific knowledge in air transport technology
- 32 - To capture a greater share of the world freight market
- 33 - To improve international balance of trade and balance of payments
- 34 - To improve government/industry cooperation in civilian cargo transport development
- 35 - To improve the profitability of aircraft manufacturing
- 36 - To create new markets geographically and among commodity sectors
- 37 - To build upon existing air terminal locations
- 38 - To offer containerized, package, and general cargo service
- 39 - To offer a reasonable system of cargo accounting and documentation
- 40 - To meet national air cargo needs and reduce international balance of payment problems, while minimizing detrimental impacts



HIERARCHICAL OBJECTIVE STRUCTURE

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CHAPTER 1



NETWORK DESIGN

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CHAPTER 1

NETWORK DESIGN

Introduction

A transportation network consists of areas to be served, nodal points, and connecting lines between nodes.

An efficient network seeks to equalize service areas which should result in more equal user cost throughout the system. Nodal points of this system are airports and air terminals that, ideally, are capable of providing the service called for by the service areas. Connecting lines are the routes that connect nodal points to each other and to major hubs that serve as collection points for whole countries or continents, depending upon size. Connecting lines are further modified by frequency of use and balance of flow in both directions of each link. Finally, the type of aircraft that fly the connecting routes are part of the network and should be suited to the length of lines and density of flow as well as being efficient to load, fly, and unload.

In what follows, node location is treated first from theoretical implications derived from central place theory (ref. 7). This is followed by a pragmatic treatment of the closely associated problems of routing and scheduling in Section 1.2. The routing (connectivity design) and scheduling discussion is prefaced by a description of the needs of the shipper relative to routing and scheduling. The discussion of routing and scheduling is followed by a discussion of network economics in Section 1.3. This, in turn, is followed by a discussion of cargo handling capacities and potential at existing airports in Section 1.4, by the implications of intermodal transfer upon network design in Section 1.5, and finally by the closely allied problems of aircraft payload and fleet-size in Section 1.6.

1.1 THE NETWORK

1.1.1. Theoretical Design of Network

The ideal air cargo transportation network has as its goal the economic transportation of all air-eligible cargo in the United States; it also is to provide links, gateways as it were, with an international network comprising the major continents of the world.

The collection point of all goods that need to be transported by air should be located in the center of a circular area. This same center, of course, can also serve as the final distribution point from which all goods are delivered, at equal cost, in all directions to the final destination within any service area (Fig. 1.1).

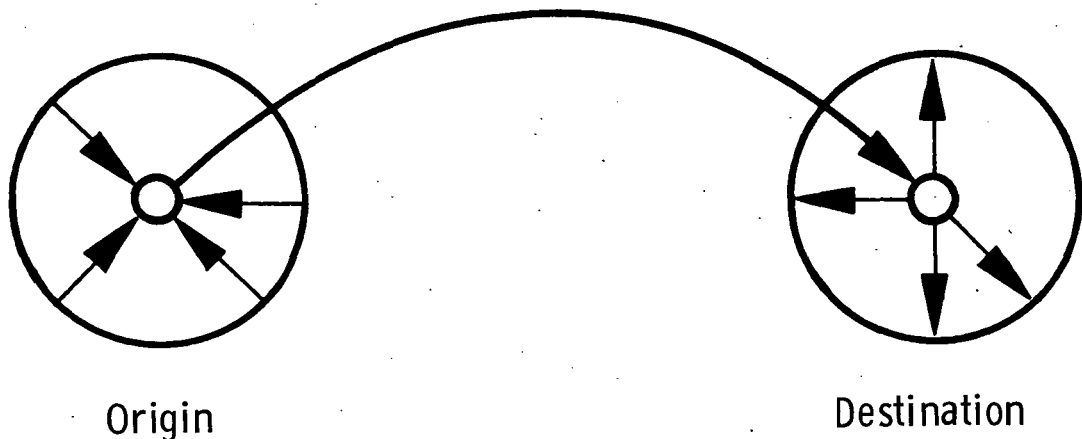


Figure 1.1 ORIGIN AND DESTINATION

The energy required to transport all goods to or from the center is as uniform as the terrain within the area. However, a series of tangent circles that cover all available space would leave unserved areas between them (Fig. 1.2). Hence, for total service, the circles should overlap and divide the space between them, producing a system of nesting hexagons. Hexagons represent the optimum compromise to circles. They have the advantage of covering all space that needs to be serviced (Fig. 1.3).

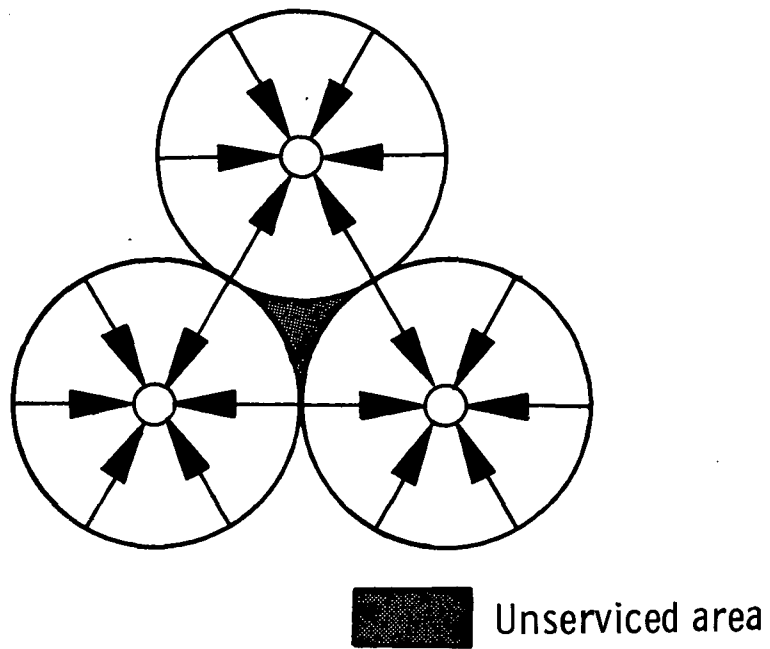


Figure 1.2 UNSERVICED AREAS

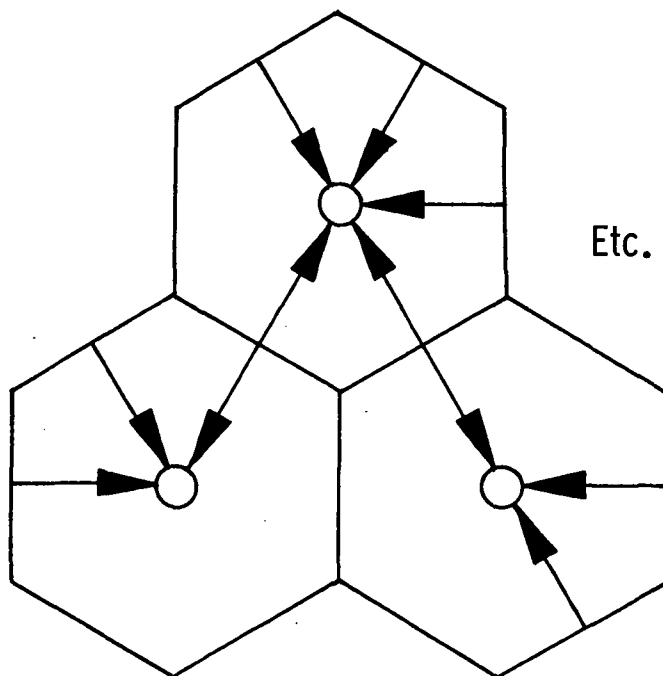


Figure 1.3 HEXAGONAL SERVICE AREAS

The hexagon pattern applied to the continental United States represents the lowest order of the network hierarchy of areas; this area is intended to be serviced primarily by surface transportation modes (Fig. 1.4). There is no distance within any hexagon that exceeds 800km (500 miles) to a central place for collection of cargo.

Distances between hexagon centers are closer to 1000km (600mi) which represent distance minima where air transportation by medium sized, intermediate distance aircraft can compete in time and cost with rail or truck. These distances represent the next larger hierarchy of hexagons (Fig. 1.5). It is here that the domestic air cargo industry will make major inroads in the surface transportation modes. The economics of the competition can be seen from Figure 1.6 and Figure 1.7, especially between trucks and long haul aircraft.

The continents as service areas represent the largest of the three sets of hexagons. The theoretical nesting of Figure 1.8 is merely to illustrate that all land masses can be serviced without gaps. Even if Asia and Australia were to be separated, as in Figure 1.9 (in order to come closer to the reality of distribution of continents), the interesting observation can be made that the distances between continents are fairly uniform (Table 1.1). The importance of this fact is that the technology exists to link continents in an air transportation network of fairly uniform service areas and distances. Aircraft like the B-747 or the C-5 are now in service over such distances (Table 1.2). Of course, countries like the Soviet Union and the United States have distances within their national boundaries (Table 1.1) that approach intercontinental distances and a detailed map would tend to show more than one super hub.

The hierarchical arrangement of service areas has the advantage of making available to the shipper economy of scale: The larger the distance to be shipped in any one haul, the lower the unit cost of goods shipped by any given mode. As a corollary to this principle, the larger the carrier, the lower the unit cost of a good shipped. The larger aircraft can negotiate the longer hauls and, hence, reduce unit cost. Both the United States and the Soviet Union can avail themselves of the largest aircraft over very long hauls and thereby lower the unit cost of goods transported within their boundaries. Over such distances, the time-cost advantage of the long air haul combined with reduced inventory and storage needs tend to equalize direct operating costs (DOC) between air mode and overland transportation (Figs. 1.6 and 1.7). Transportation of a single container over a very short distance by, say, helicopter will be costly; only extreme time pressure in a congested urban center around a given airport would warrant such an expense.

Central places in a mixed hierarchy represent an equilibrium of "least work" in an energy flow system (ref. 1). Central places are concentrations of human beings and their activities in any location ranging from villages, to towns, to cities, all the way to metropolitan areas. The term "mixed" refers to organization of space according to market areas, transportation routes, and economy of size in a complex social economic society. The mixed hierarchy here represented combines the market areas, wherein goods are collected primarily by surface transportation, with a transportation hierarchy of larger central places, and active airports, connected by direct air service with each

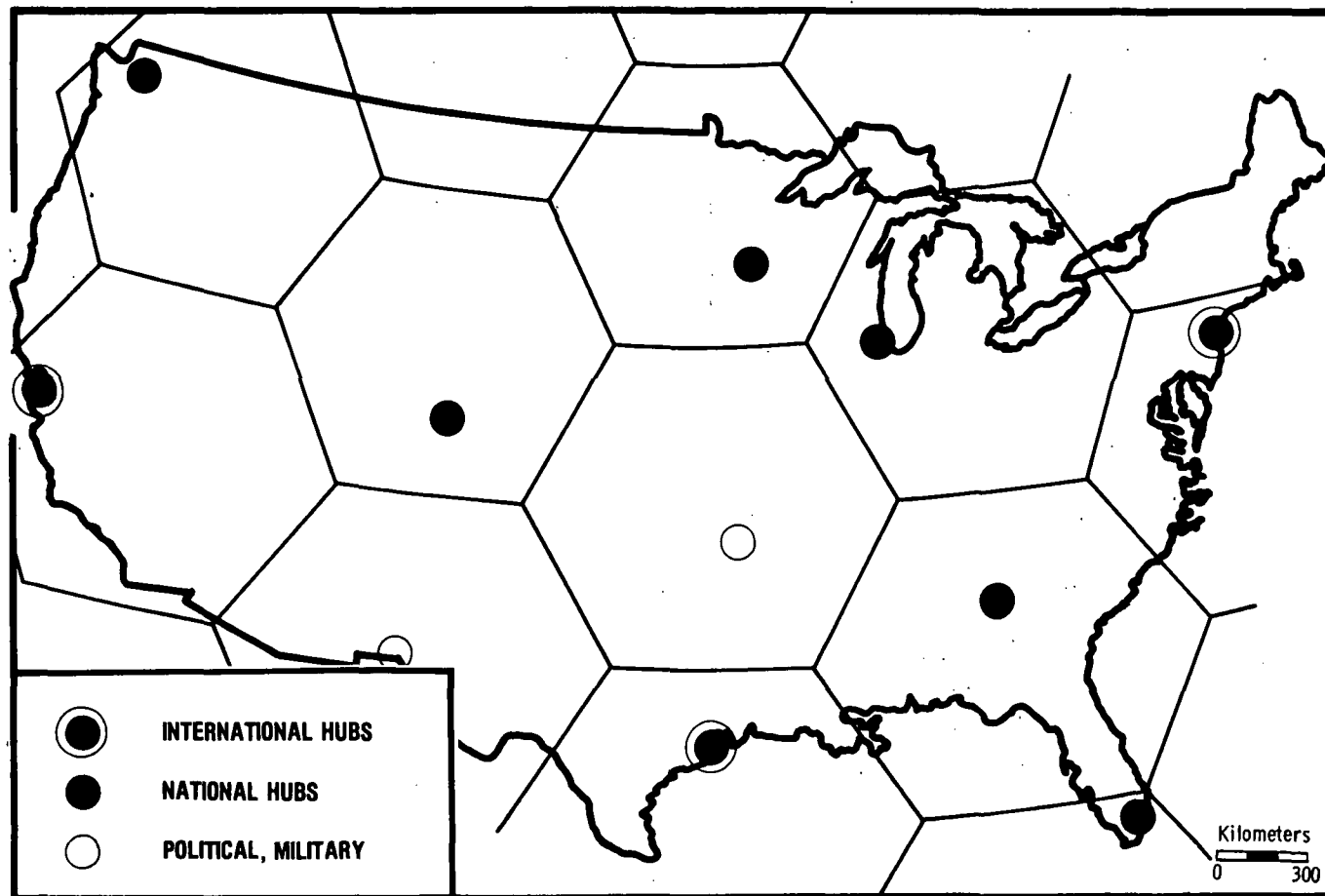


Figure 1.4 AIR CARGO NETWORK AND SERVICE AREAS

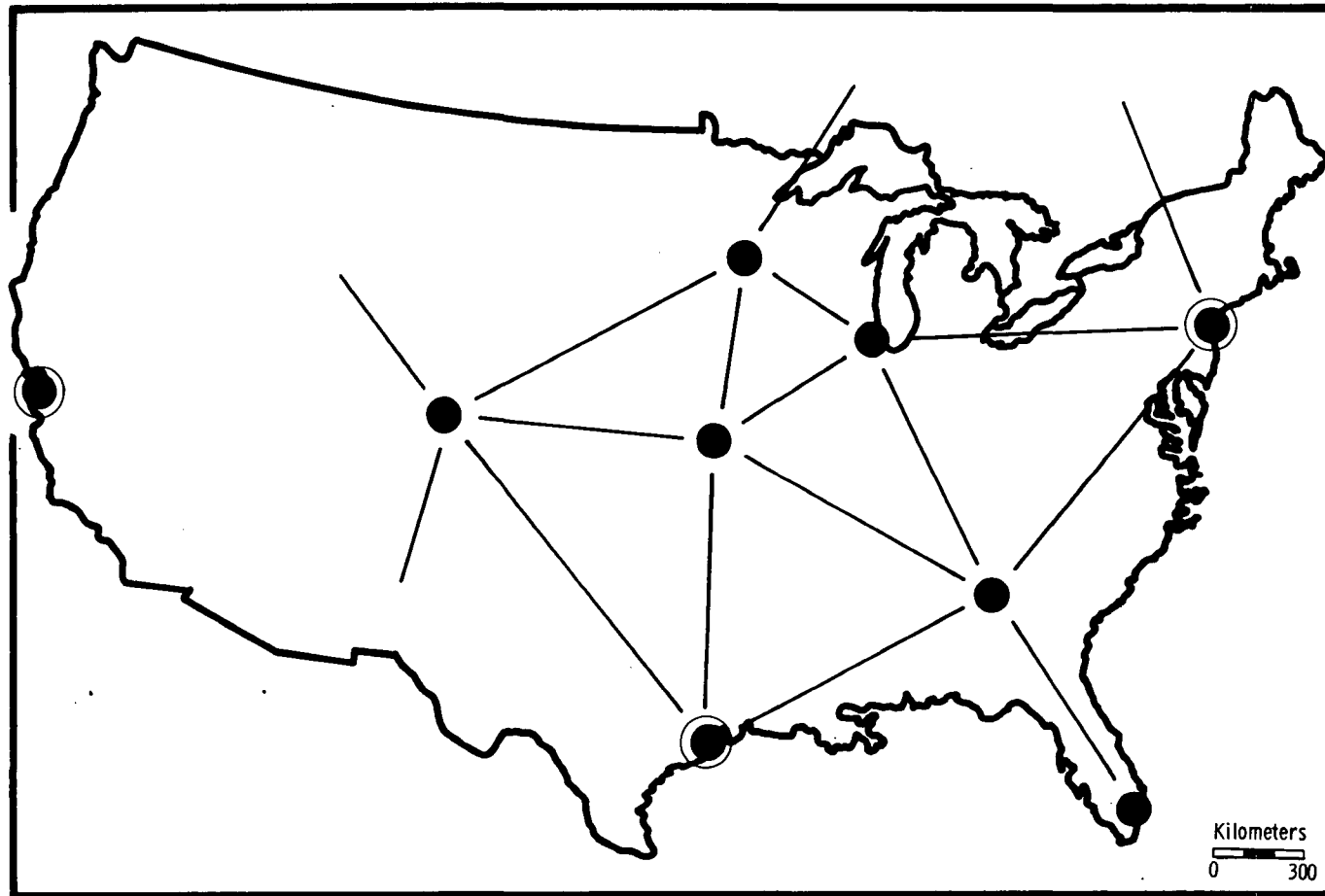


Figure 1.5 SECOND ORDER HIERARCHY

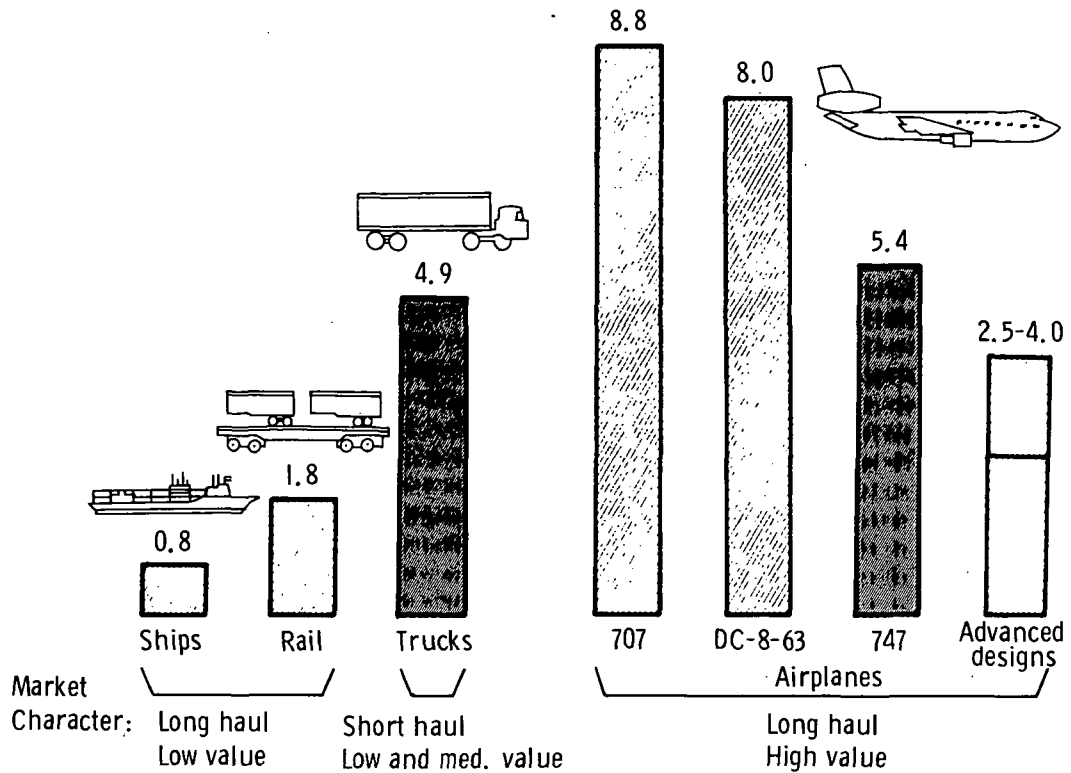


Figure 1.6 TRANSPORTATION COST IN CENT PER TON-MILE (Source: The Russellville Concept, An Intermodal Cargo Transportation System, Russellville, Arkansas, February 1978, p. 47).

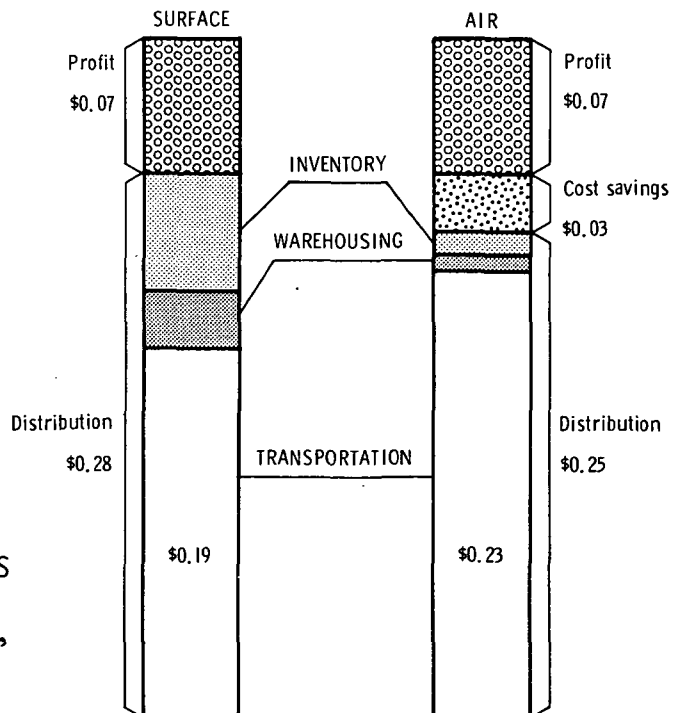


Figure 1.7

THE CONCEPT OF TOTAL DISTRIBUTION COSTS (Source: The Russellville Concept; An Intermodal Cargo Transportation System, Russellville, Arkansas, February 1978, p. 43).

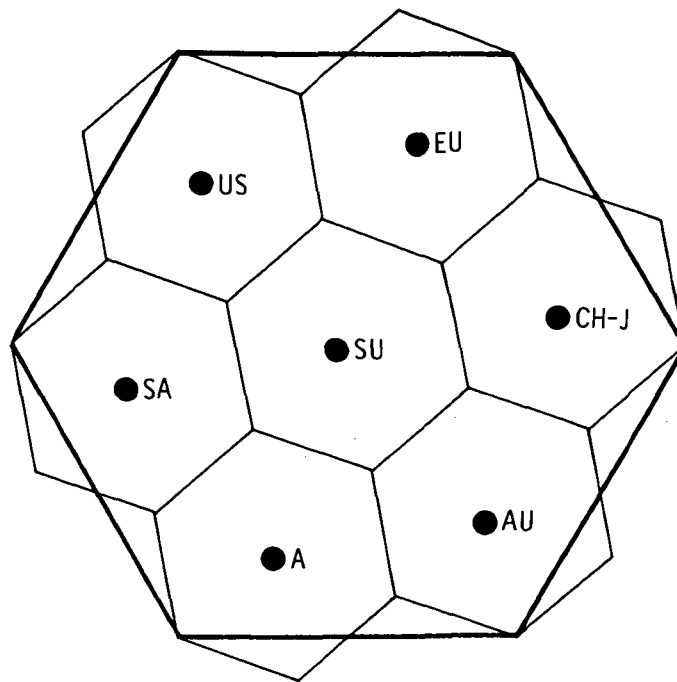


Figure 1.8 WORLD SERVICE AREAS

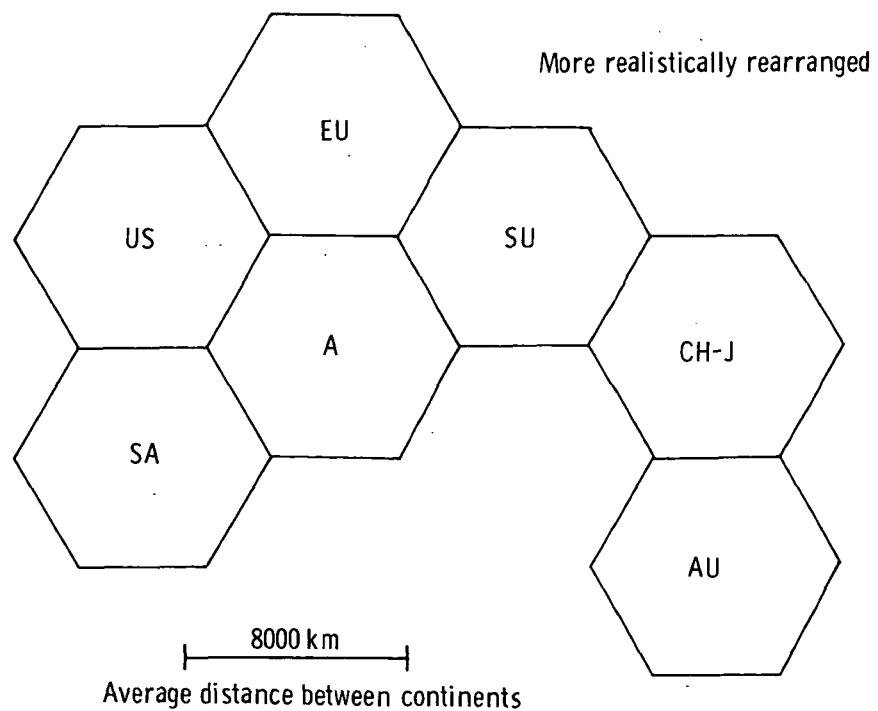


Figure 1.9 WORLD SERVICE AREAS (MORE REALISTICALLY REARRANGED)

Table 1.1

TYPICAL DISTANCES AND AVERAGES

	Miles	Kilometers
North Atlantic	4460	7178
North Pacific	6370*	10,252
North - South America	5320	8562
U.S. - Middle East & Africa	7000*	11,265
Europe - Far East/Australia	10,500*	16,898
Europe - Africa	3300	5311
Europe - Middle East	2500	4023
Europe - L/Developed America	5300	8530
Japan - L/Dev. Far East & Australia	2500	4023
Japan - Africa & Middle East	8000*	12,875
Japan - L/Developed America	<u>11,000*</u>	<u>17,703</u>
Average distance	4140	8926
*usually two stops; see below		
U.S. - Australia		
Los Angeles - Honolulu - Sydney	2556,5067	4729,9376
New York - Honolulu - Sydney	4893,5067	9220,9376
U.S. - Africa		
New York - Dakar - Nairobi	3805,1498	7041,2722
Kinshasa - Lisbon - New York	3360,3367	6217,6230
U.S. - Asia		
Los Angeles - Honolulu - Tokyo	2556,3854	4279,7131
New York - Fairbanks - Tokyo	3278,3522	6065,6517

Table 1.2

AIRPORTS IN U.S. AND CANADA WITH B-747 SERVICE, 1978 (Ref. 46)

Airport	No. Airlines flying B-747	No. Airlines flying B-747 F/C*	No. Airlines Serving Airport
J.F. Kennedy (NYC)	18	5	72
O'Hare (ORD)	9	3	47
Los Angeles (LAX)	7	0	43
San Francisco (SFO)	7	0	33
Honolulu (HNL)	7	0	24
Boston (BOS)	5	2	36
Toronto (YYZ)	5	1	22
Seattle-Tacoma (SEA)	4	2	21
Mirabel (Montreal) (YMX)	4	2	23
Dulles (IAS)	4	0	16
Detroit Metro (DTW)	3	0	28
Anchorage (ANC)	3	1	18
Miami (MIA)	2	0	54
Houston (IAD)	2	1	22
Las Vegas (LAS)	2	0	15
Vancouver (YVR)	2	0	9
Hilo (ITO)	2	0	8
Dallas-Ft. Worth (DFW)	1	0	23
Denver (DEN)	1	0	27
Philadelphia (PHL)	1	1	20
Minneapolis-St. Paul (MSP)	1	1	20
St. Louis (STL)	1	0	22
Pittsburg (PIT)	1	0	14
Phoenix (PHX)	1	0	10
Montreal Int'l. (YUL)	1	0	14
Milwaukee (MKE)	1	1	11

*The B-747F and B-747C are coded as a separate category in ref. 46 as all-freight versions with nose loading main deck. Column 3 numbers are included in the numbers listed in Column 2, though the same airline may fly both all-cargo and belly 747's.

other. Each continent can be considered as having one large "hub" airport that is connected with lower order airports as if by "spokes". Such a system is referred to as a "hub-spoke" system, indicating a hierarchy of areas and services.

1.1.2. "Fitting" Central Place Theory to the Reality of the American Landscape

A glance at Figure 1.4 will show that the hexagonal service areas covering the contiguous United States are fairly equal but the transportation collection points are not always in the centers. The specific choice of centers was influenced by the intention to utilize existing facilities and technology as much as possible. Another aspect of reality that will tend to distort the theoretical lattice is that the area of a service circle, in this case a hexagon, of either a hub or a spoke terminal will tend to be proportional to the amount of cargo traffic generated within it (ref. 2). In other words, sparsely settled areas tend to have larger spatial service areas than densely settled areas, even though they may be "equal" in total service.

All of the terminal hubs selected have runways that can accommodate large aircraft like the B-747 (ref. 3); the preferred width is 61m (200ft) although 45m (150ft) will also do (Also compare Table 1.2).

Seattle, San Francisco, and Los Angeles are located in the western part of their hexagonal service areas, as is Chicago. This location corresponds to the reality of commercial, industrial, and demographic distribution of human activity. Thus, these cities are more properly placed in the "activity centers" of their respective areas.

Miami appears to preside over an area that is mostly water. However, Miami ranks rather high in a hierarchy of airport activity (Table 1.3), activity that is generated by its "central" location with respect to the active Caribbean area which Miami serves.

San Francisco, Houston, and New York serve the dual functions of collecting points for their respective hexagons as well as points of entry and departure for longhaul international cargos.

Finally, hexagons that center on El Paso, Texas, and Emporia, Kansas, might be good examples of two other considerations of "reality" that also influence the specific location of central places of a given network:

1. Political considerations, and
2. National defense considerations.

Russellville, Arkansas, has been selected as an example of the political process at work as it contributes to the industrial and economic evolution of the cultural landscape (ref. 4). There are other suggestions for the establishment of similar all-cargo freightports in Coalinga, California, the Pacific International Freeport Center near Ogden, Utah, as well as the International Air Cargo Distribution Project planned for Northwestern Nevada: "in the

Table 1.3

FORTY LARGER AMERICAN AIRPORTS AND THE NUMBER OF CERTIFIED
CARRIERS SERVING THEM, RANKED BY FREIGHT ENPLANED, 1977

F	AL	AF	AIRPORT	FT	DP	F/P	Pax	P
1	47	78	Chicago (ORD)	366	293	2500	19.2	1
2	72	112	N.Y.-J.F. Kennedy (NYC)	365	108	6800	7.7	5
3	43	87	Los Angeles (LAX)	335	145	4600	10.9	3
4	33	64	San Francisco (SFO)	192	101	3800	7.0	8
5	21	26	Seattle-Tacoma (SEA)	143	56	5100	3.6	20
6	54	54	Miami (MIA)	134	84	3200	5.2	12
7	22	21	Atlanta (ATL)	132	221	1200	15.0	2
8	28	32	Detroit (DET)	104	81	2550	4.3	13
9	23	32	Dallas-Ft. Worth (DFW)	94	148	1250	8.4	4
10	24	16	Honolulu (HNL)	89	47	3800	5.3	11
11	36	38	Boston (BOS)	81	100	1600	5.7	10
12	27	17	Denver (DEN)	63	122	1050	7.1	7
13	20	28	Philadelphia (PHL)	53	69	1550	3.7	18
14	18	21	Cleveland (CLE)	49	51	1990	3.1	22
15	20	14	Minneapolis-St. Paul (MSP)	47	68	1400	3.8	16
16	20	36	Newark (EWR)	43	65	1300	3.6	19
17	22	42	Houston (IAH)	41	68	1200	3.8	17
18	22	19	St. Louis (STL)	29	90	650	4.1	15
19	20	10	N.Y.-La Guardia (LGA)	27	132	400	7.6	6
20	15	26	Baltimore-Washington (BAL)	23	63***	750	1.5	*
21	14	12	Pittsburgh (PIT)	20	92	450	4.2	14
22	18	19	Washington National (DCA)	18	105	350	6.2	9
23	15	16	New Orleans (MSY)	17	47	700	2.7	23
24	20	8	Tampa (TPA)	15	58	500	2.6	24
25	10	10	Phoenix (PNX)	14	48	600	2.5	25
26	15	0	Las Vegas (LAS)	3	52	100	3.5	21
*	18	9	Anchorage (ANC)	**	**	**	**	*
*	13	11	Charlotte (CLT)	**	**	**	**	*
*	13	13	Cincinnati (CIN)	**	**	**	**	*
*	16	0	Dulles (IAD)	**	**	**	**	*
*	14	1	Fort Lauderdale	**	**	**	**	*
*	14	15	Kansas City (MCI)	**	**	**	**	*
*	16	12	Memphis (MEM)	**	**	**	**	*
*	14	8	Montreal-Int'l (YUL)	**	**	**	**	*
*	23	8	Montreal-Mirabel (YMX)	**	**	**	**	*
*	15	5	Nashville (BNA)	**	**	**	**	*
*	14	15	Portland (PDX)	**	**	**	**	*
*	12	11	Salt Lake City (SLC)	**	**	**	**	*
*	14	16	San Diego (SAN)	**	**	**	**	*
*	22	10	Toronto (YYZ)	**	**	**	**	*

* Not ranked in the top 26. ** Data not available *** Half of flight movement

evolution of transportation decision making economic importance (will) decline in relative importance as decisions become more politicalized" (ref. 5).

The establishment of a totally new all-cargo air terminal at Russellville was conceived by a group of businessmen and industrial leaders. They proceeded to enlist senators and congressmen in their effort to build political support for establishing a dedicated all-cargo, fully intermodal air terminal in their town. Figure 1.10 illustrates the major "modes" of transportation and the "link" between them, namely the standard container, 2.44m x 2.44m x 3.05m or 6.10m or 12.19m (8ft x 8ft x 10ft or 20ft or 40ft).

It is not certain whether the Russellville group will succeed in their attempt; nevertheless, political clout and pull will have some effect upon the location of modern airports as will such other factors as commercial activity, links to other transportation modes, and available land. The same will be true with the exact location of a modern dedicated gateway freightport, now called "New York" which will serve the megalopolis "BosWash" (the congested urban landscape from Boston to Washington), and whether Dallas will get the nod over Houston, or San Francisco over Los Angeles.

There is an established commercial airport in the vicinity of El Paso, Texas, but not of the order of magnitude as shown on Figure 1.15. The hexagonal grid indicates that an airport should be developed in that vicinity, if for no other reason than strategic considerations. However, there appears to be an adequate air force base in the area, Holloman Air Force Base, which could also be converted to civilian use, thus serving as a model for civilian/military cooperation in the development of a total air cargo system.

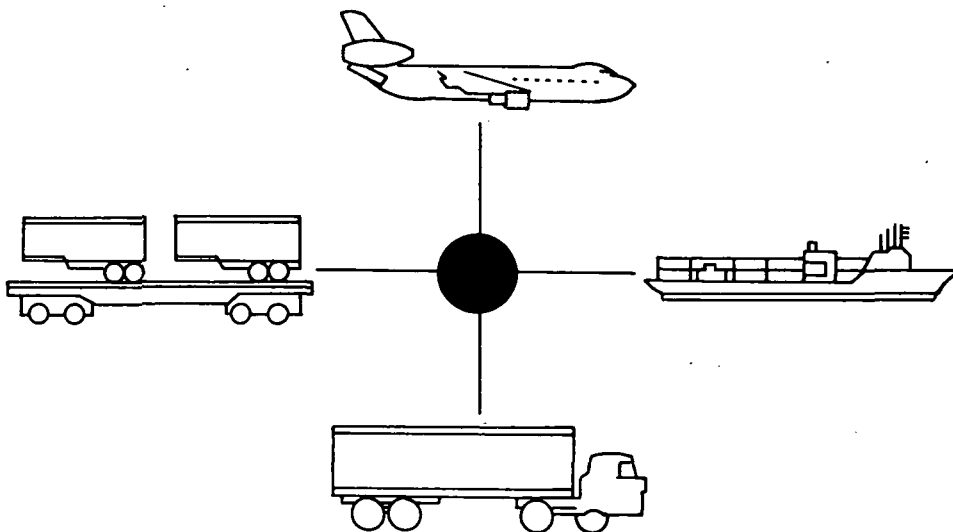


Figure 1.10 THE INTERMODAL AIR CARGO TERMINAL CONCEPT

Such a jointly used air terminal could give rise to the rules and regulations, security measures and civil freedom of action, training of crews for CRAF, and other measures needed in national emergencies.

The FAA 1976 National Aviation System Plan estimates that the total number of airports in the system will grow from 3290 in 1975 to 4066 in 1990 for publicly used and jointly used civil/military airports within the U.S. and its territories (ref. 6), "where there is a national interest in providing reasonable access to the nation's air transportation system".

1.1.3 The Relation of the Designated Centers to Other Modes of Transportation

The locations of most of the airports in or near the centers of the hexagons have developed naturally in conjunction with nearby interstate highways and major trunk railroads. The basic reason, of course, is that urban concentrations developed historically in response to fertile land and favorable communication corridors (Figs. 1.11, 1.12, and 1.13).

As can be seen from these maps based on Department of Transportation published maps and one sketch map, the suggested air terminals of the system are astride the major flow of goods in the U.S. Between them, these airports also handle the major air cargo flows as shown on the percentage distribution map of air freight activity at major U.S. domestic airports, for 1976 (Fig. 1.14). Boston, New York, Philadelphia, and Washington will be served by the new airport to be built, called New York in the proposed network.

1.1.4 The Location of New, Dedicated Major Hub "Gateways"

San Francisco, New York, and Houston have been designated as "gateways" to the international network because of their location with respect to Europe, Africa, South America, and the Orient. The intent is to create entirely new and dedicated cargo-only freightports that have easy access to all other major modes of transportation, i.e., rail, highway, and water. These freightports will have to be located away from present urban surface and air lane congestion as none of the existing major airports in the areas concerned will be able to absorb the expected increase in container cargo anticipated for the 1990-2015 target period envisaged for this system (See Figure 1.15 for anticipated growth in air activity in 1990).

In view of the fact that approximately 50% of all cargo in 1990 will continue to be carried as "belly" cargo both in passenger craft and in dedicated cargo planes, albeit in standardized containers, some provision has to be made to link the freightports with existing mixed passenger and cargo terminals for hub-spoke transfer of containers in either direction. Such links could be fully automated rail links (like the San Francisco BART System) or very limited access roads between the airports for special rubber wheeled trains or trucks. The federal government favors the planning of land for new, large airports. According to an act, signed by President Ford July 12, 1976, the Federal Government will participate in 75%-90% of the cost of purchasing land interests to insure that neighboring land use is compatible with airport operations (ref. 6).

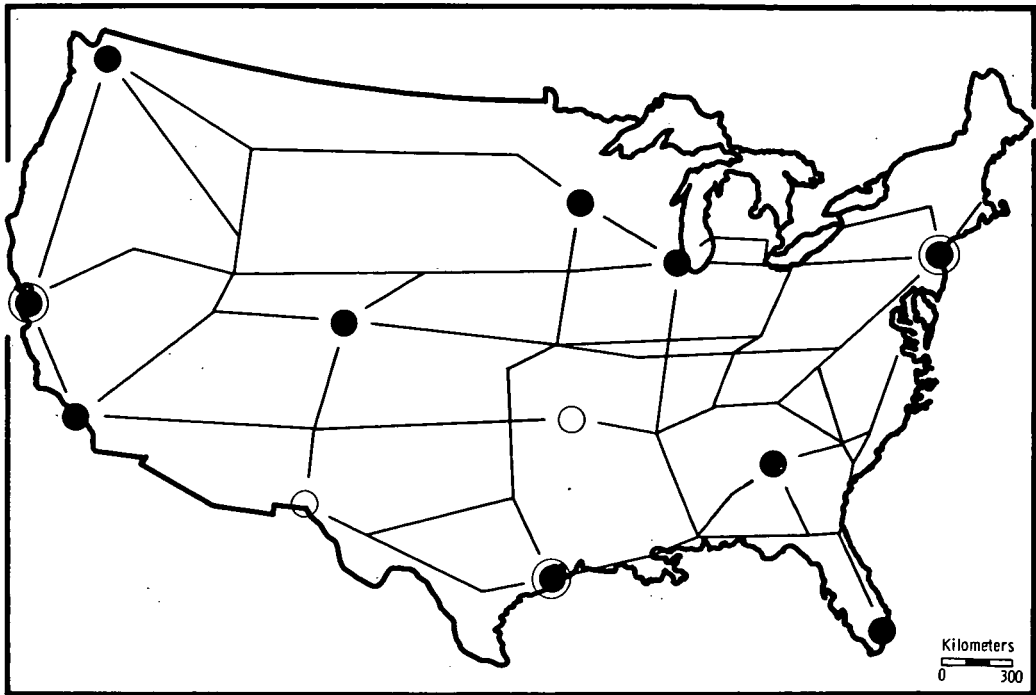


Figure 1.11 INTERSTATE HIGHWAYS (Ref. 6)

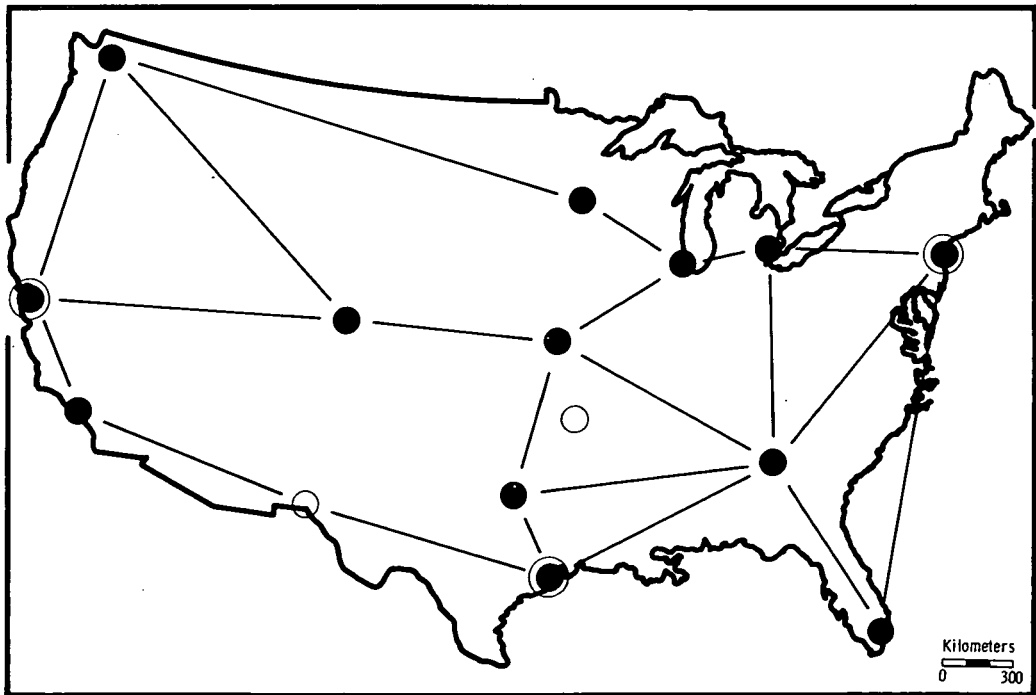


Figure 1.12 CLASS A OR POTENTIAL RAILWAYS (Ref. 6)

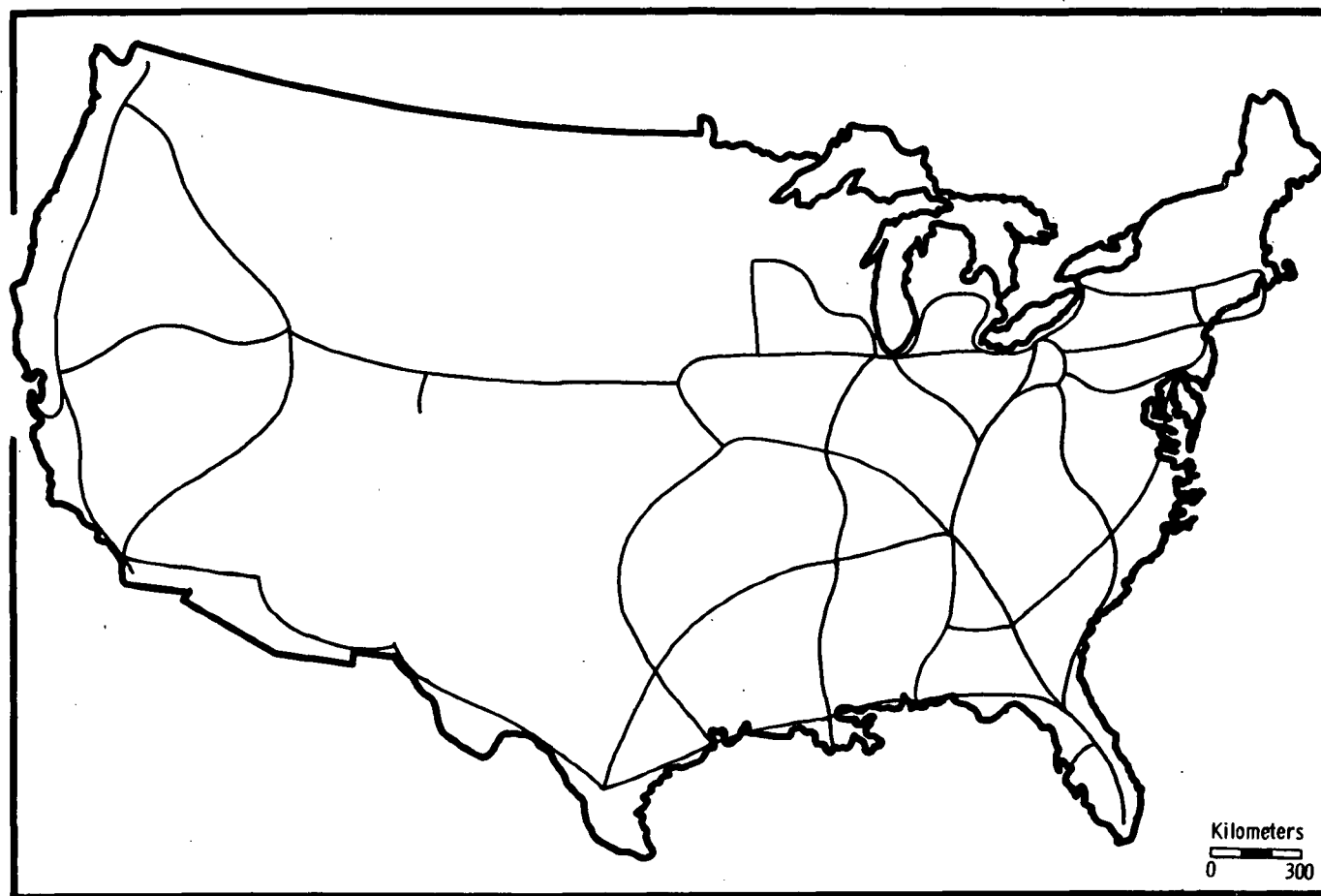


Figure 1.13 INTERMODAL NETWORK (RAIL & ROAD)

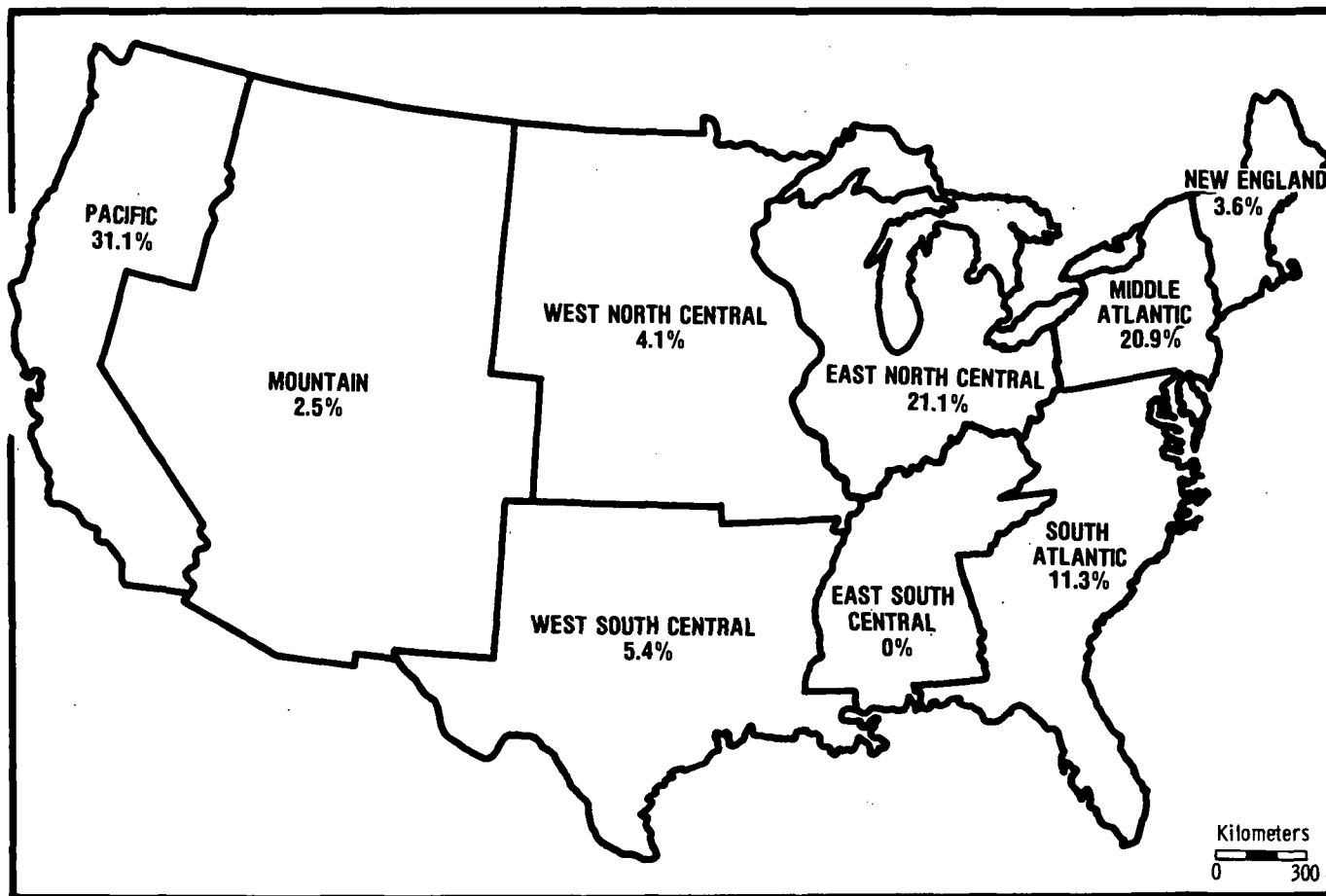


Figure 1.14 PERCENTAGE OF DISTRIBUTION OF AIR FREIGHT ACTIVITY
(Source: Douglass Class Report, 1978, p. 16).

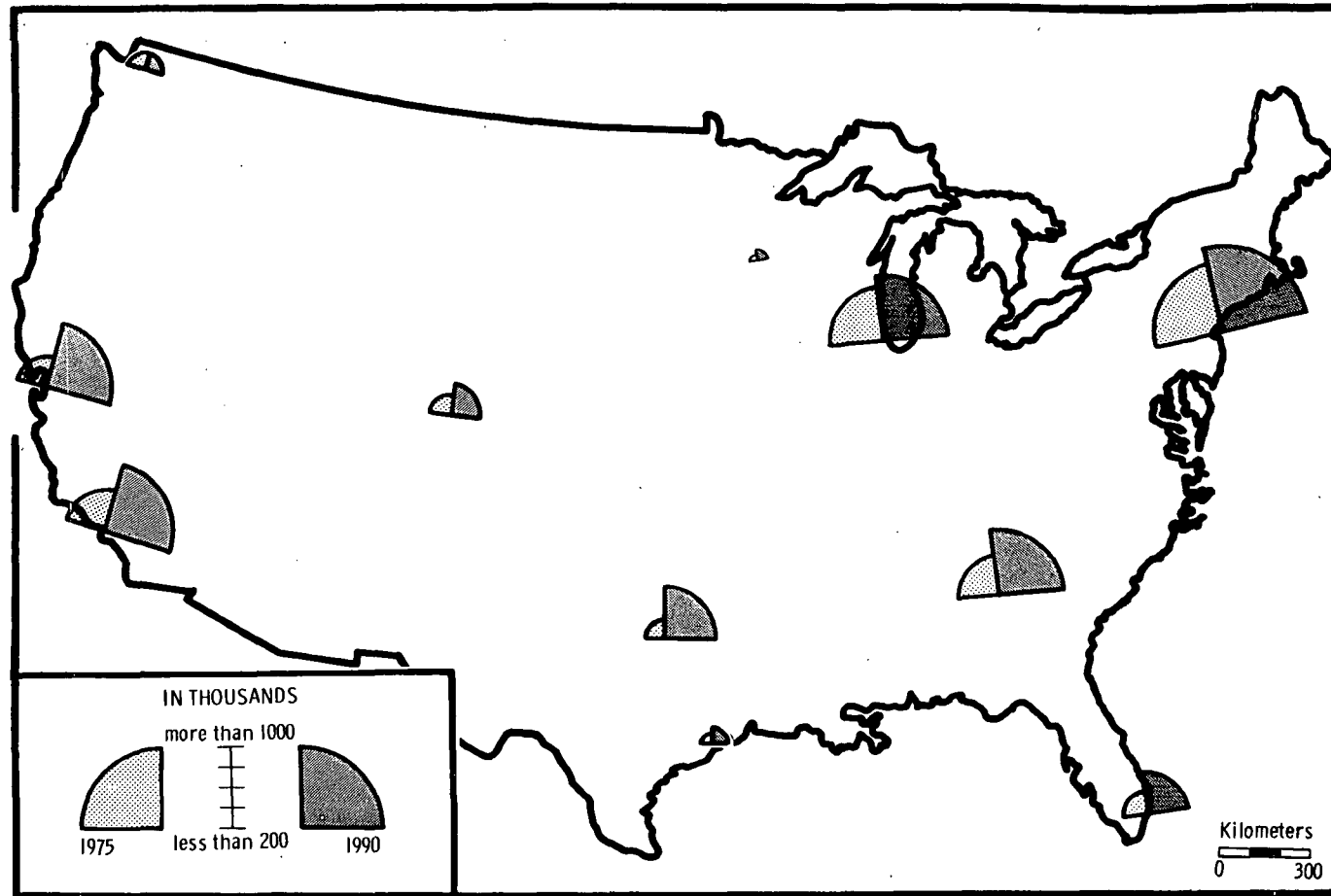


Figure 1.15 1975 & 1990 AIR OPERATIONS AT LARGE HUBS (Ref. 6)

Table 1.4

A SUGGESTED SCHEDULE FOR OVERNIGHT DELIVERY

Event	Pacific Time	Eastern Time
Truck leaves consignor at Olympia	6:00 p.m.	9:00 p.m.
Truck arrives Seattle Airport	7:00 p.m.	10:00 p.m.
Feeder-plane departs for S.F.	8:00 p.m.	11:00 p.m.
Feeder-plane arrives at S.F.	9:30 p.m.	12:30 a.m.
Hub-plane departs for N.Y.C.	10:30 p.m.	1:30 p.m.
Hub-plane arrives at N.Y.C.	2:30 a.m.	5:30 a.m.
Feeder-plane departs for Albany	3:30 a.m.	6:30 a.m.
Feeder-plane arrives at Albany	4:00 a.m.	7:00 a.m.
Truck leaves Albany Airport	5:00 a.m.	8:00 a.m.
Truck arrives at consignee	6:00 a.m.	9:00 a.m.

(from Olympia, Wash. to Albany, N.Y.)

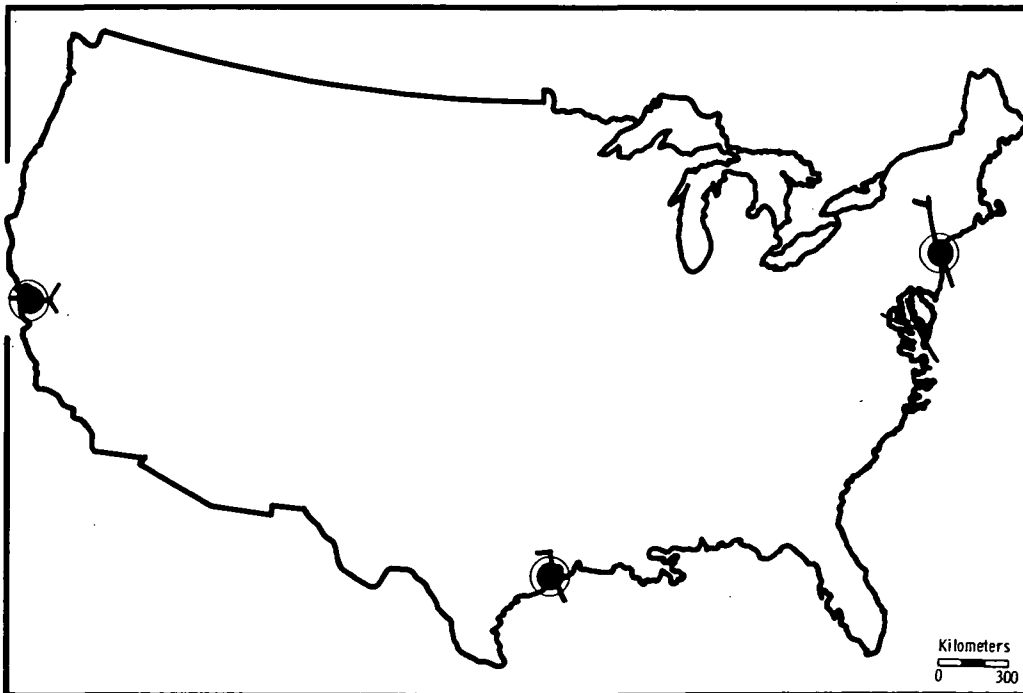


Figure 1.16 DEEP WATERWAYS AT INTERNATIONAL HUBS (Ref. 6)

The average distance flown between these major gateway hubs is of the order of 5000-8000km (3500-5000 miles), suitable for planes like to Boeing 747 or the DC-10. Most of the world's major airlines are now using the B-747 precisely for such missions, and at least 12 carriers employ all-cargo versions of the B-747 (Table 1.4).

To accommodate the water mode for moving containers, there are existing deep waterways near the proposed major hubs (Fig. 1.16). At this stage in the development of standardized containers, the specifications for seaborne containers are not quite compatible with those called for by the air transport industry, especially as far as tare weight and bottom surface is concerned. While some containerships carry their own lighter barges capable of carrying containers along canal access ways, the interchange between air and water may not carry a significant percent of the total cargo even during the cargo period planned for by this system. Nevertheless, there is no harm including the possibility as long as the waterways do exist and the potential is there.

Finally, one other aspect of long range planning incorporated into the design of freightports should be considered. It is conceivable that, by the year 2000:

- 1) a fully integrated, intermodal air cargo transportation system is in place,
- 2) all-cargo, long range aircraft are fully operational and fully utilized,
- 3) the prospects indicate a continued growth of air cargo business, and
- 4) an even more interdependent world industrial and commercial economy has developed.

At that point, the need for an advanced air cargo craft such as the twin body (C-XX) or the span loader (DLC), which are now on the drawing boards of the major airframe companies, will have been ascertained. In anticipation that new large aircraft will be called for, modern airports now being planned should set aside acreage that could then be developed with appropriate runways and buildings to form the ground support infrastructure for this new generation of aircraft.

1.1.5. Remarks

The hierarchy of hexagonal areas provides for service to all areas, from the smallest and least efficient units to large continents utilizing efficiency of scale. No pure network organization will do justice to all special cases that have developed historically; there simply is not enough flexibility in any single system or concept. Elsewhere in this chapter special cases of networks have been discussed. The above network is intended to serve as a unifying framework.

The impact of the system upon the landscape of the United States will be primarily in the vicinity of the proposed new air cargo terminals, i.e., the San Francisco, the New York, and the Houston regions. The U.S. Secretary of Transportation sees need for at least ten new major airports for the year 2000 (refs. 5,7,8,9). It is here proposed that the three hub freightports be placed in uncongested, rural settings, preferably utilizing wasteland, certainly not prime farmland. It may be necessary to build additional limited access roads which will produce the usual consequences for nearby populations, streams, and wild life (see Section 5.3). The separation of this cargo traffic from passenger traffic at existing mixed-use airports will contribute to an easing of congestion both of air lanes and urban access roads. Subsequent development of industrial parks around new hubs can be monitored carefully and controlled by local authorities as part of the overall planning and design of the new airports.

1.2 CONNECTIVITY AND SCHEDULING

The preceding section of this chapter considered the probable locations of the cargo ports. These locations represent the nodes (terminals) of the network. In this section, the edges (links or routes) connecting the nodes are considered. In addition to the problem of edge determination, the closely allied problem of scheduling is treated in this section. Important considerations relative to scheduling include such disparate concerns as backhaul, shippers needs, air freight carrier (AFC) network, competitive AFC's, airport authorities and terminal availability, curfews, regulations, and the Postal Service. These topics will be discussed at some length.

Out of this deliberation will come important implications for aircraft size. In fact, several air carrier planners (notably Pollack, ref. 10 and 11, and Glenn, ref. 12) allude to the almost parallel planning required to solve the scheduling and fleet planning problems. This is depicted in Figure 1.17. Additional details regarding aircraft mix will be discussed in Section 1.6. The intimate relationships between network connectivity, scheduling, and fleet sizing, however, are discussed in this section.

It is worth noting that even though the network, fleet-sizing, and scheduling problems should be solved simultaneously (or in concert), any formal combinatorial optimization approach is computationally infeasible. For a simple combined problem consisting of a 40-node network and two different aircraft sizes, the combinatorial design space is of dimension nearly 13 000. Considering that a combinatorial design space problem of dimension 40 can take weeks to find the extremum on a high-speed computer, it becomes understandable as to why the combined, total optimization problem cannot be solved. It must be solved as a collection of subproblems, each of whose dimensionalities is considerably reduced by heuristic design rules. It becomes necessary, therefore, to treat these subproblems in concert and separately as well. They are considered jointly here and dealt with as isolated subproblems later.

In addition to scheduling aircraft, the total scheduling problem also involves the use of any surface transport required to move the freight from the shipper's dock to the freightport and from another port to the consignee's dock. Thus the total scheduling problem requires coordination of the operations of the air carriers with that of the surface carriers, all of which must be tailored to the shipper's needs. In this design, the freight forwarder is assumed to handle the surface transport, and the freight forwarder adjusts his schedules to accommodate both shipper and air carrier. Even so, the air carrier's schedule can be fitted appropriately into the transportation windows needed by the freight forwarder to satisfy the customers. It is conceded that a vertically integrated carrier system may be operational by 1990 in which one company handles all surface and air transport, but this certainly is not the usual case today. The total system is depicted in Figure 1.18. It is apparent that surface transport and air transport schedules must be coordinated.

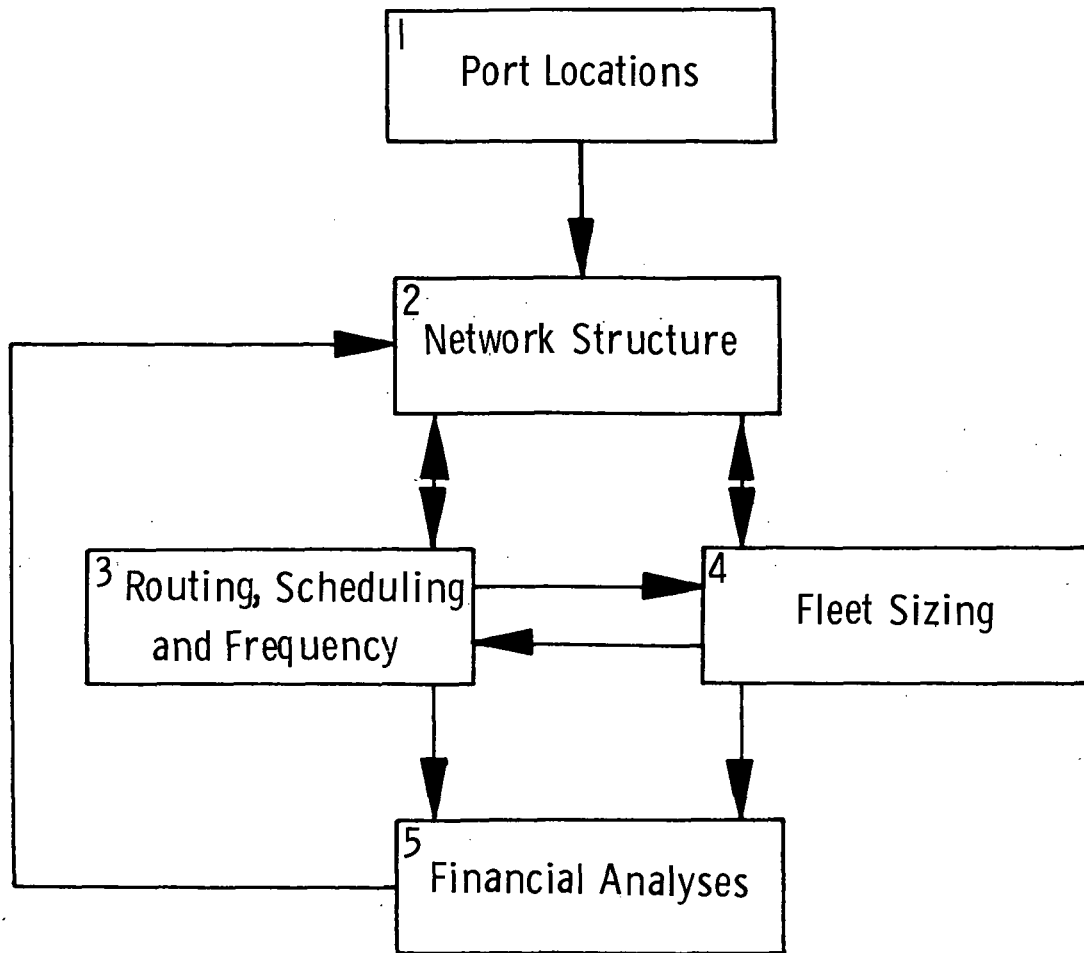


Figure 1.17 BASIC COMPONENTS IN AIR FREIGHT CARRIER PLANNING AND THEIR INTERACTIONS

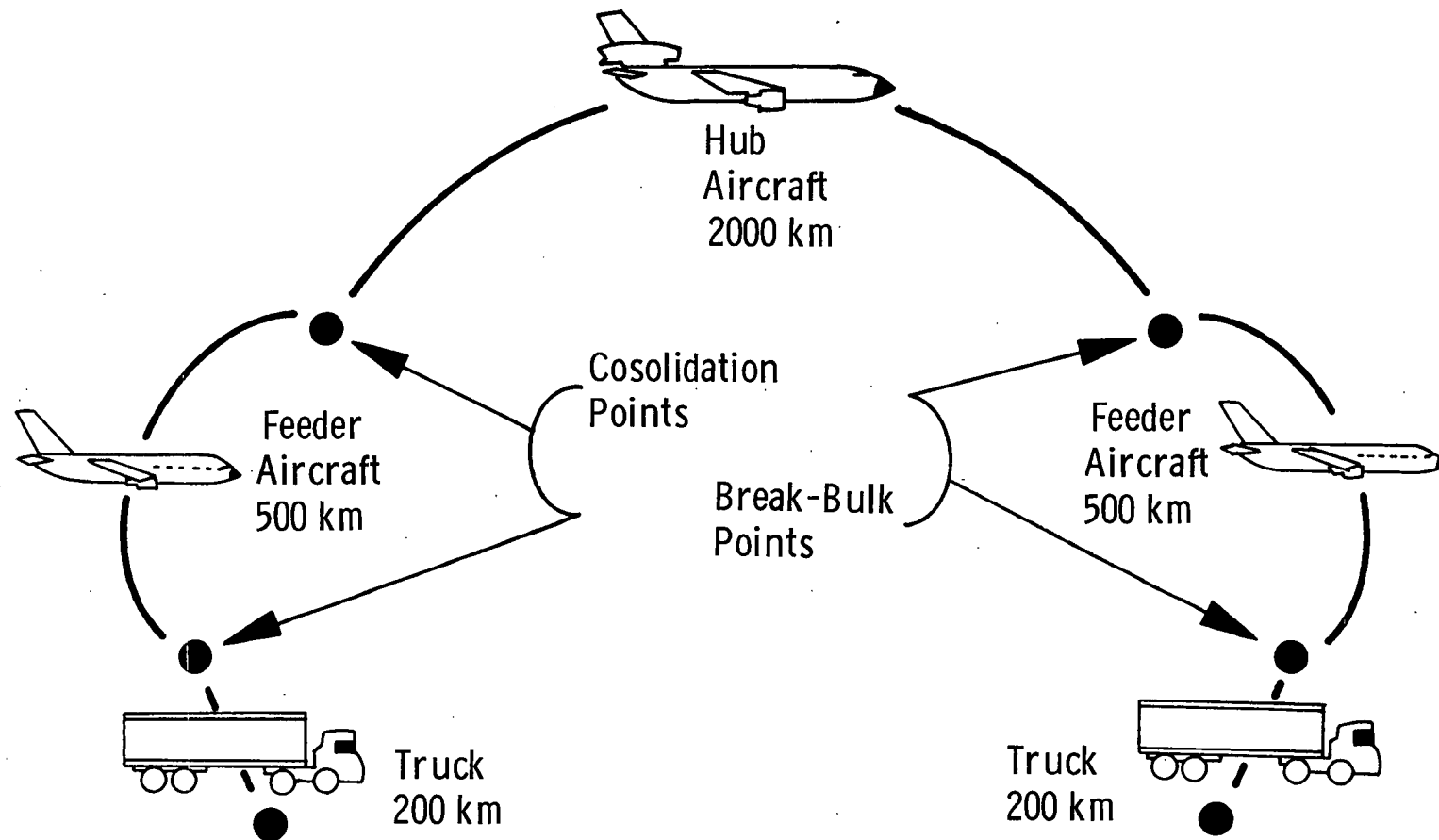


Figure 1.18 A PICTORAL REPRESENTATION OF AN AIR CARGO SYSTEM SHARING INTERFACES WITH TRUCK, RAIL, AND SHIP TRANSPORT SYSTEMS

In what follows, a discussion of the needs of the shipper is followed by a discussion of connectivity design in terms of direct versus hub-spoke approaches. Formal network designs are proposed which are compatible with the needs of the shipper, the air carrier, and other interested parties.

1.2.1. Characteristics of the Shipper (Consignor)

At the outset of the scheduling and connectivity design process, it seems appropriate to consider the needs of the shippers in order that the cargo system will accommodate their transportation requirements. As pointed out by Pollack (ref. 10), cargo tends to arrive at the airline during a short concentrated period in the latter part of each workday. The airline, in turn, has strong pressures to fly at night so that the cargo is ready to be delivered to the customer in the morning of the next workday. Both the departure and the arrival distributions are thus sharply unimodal. The allowed cargo shipping time is approximately one half day, and then it usually increases in increments of 24 hours.

Glenn (ref. 12) also characterizes the shipper in an analogous way.

"He wants as many flights as possible in the late evening, so that he can clear the products manufactured that day. As a rule, he is not interested in flights on weekends, when his plant is not producing. He wants through flights, as he recognizes that, on occasion, the paperwork which accompanies his shipment sometimes goes astray when the shipment must be transferred from one flight to another."

These sentiments are corroborated by similar statements found in Taneja (ref. 13) who also maintains that shippers prefer late afternoon and evening flights which are nonstop or direct. Taneja maintains that the Postal Service is interested in flight departures ranging from 6 P.M. to 1 A.M. and in arrivals from 4 A.M. to 6 A.M.

In addition to in-transit time, the shipper is also concerned about cost of transshipment and possible losses due to breakage, theft, and pilferage. With the exception of cost, all of these factors comprise the quality of service which the shipper receives from the total air cargo system including the air carrier, the freight forwarder, any terminal processors, etc.

1.2.2. Connectivity Trade-offs: Direct vs Hub-Spoke

Previously, a network was described as consisting of nodes and edges, as shown in Figure 1.19 below. It is customary to speak of connectivity as the degree to which the nodes of the network are connected by edges. The minimum number of edges in the network is the number of edges required to connect all the nodes. A minimum edge network is one with very low connectivity, whereas a network with a great many redundant edges, such as one in which an edge proceeds from every node to every other node, possesses a very high degree of connectivity. From Figure 1.19, the similarity between a network with low connectivity and the hub-spoke construct is apparent, whereas a network with

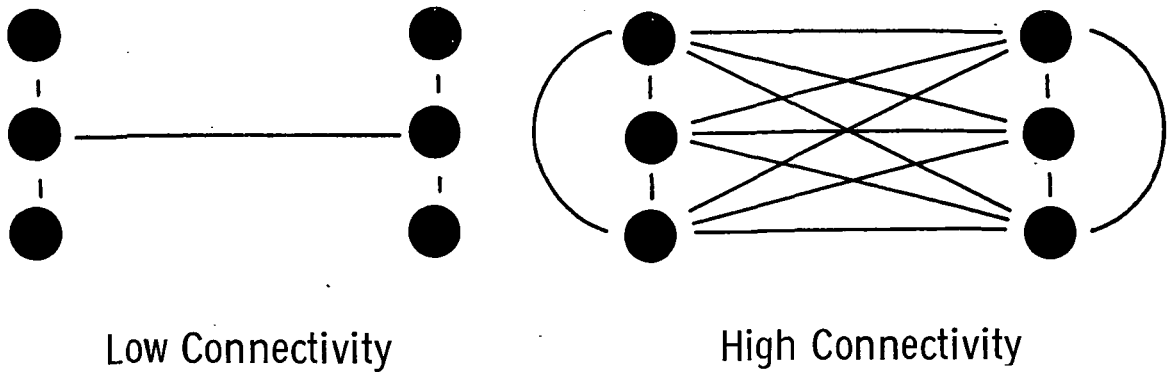


Figure 1.19 SIMPLE SIX-MODE NETWORKS ILLUSTRATING THE TWO EXTREMES OF CONNECTIVITY

high connectivity approximates our understanding of direct routing. Note that in the hub-spoke network, there are five edges, whereas in the direct network there are fifteen.

Clearly, the hub-spoke arrangement lessens the number of routes. For a fixed number of aircraft, this allows a greater frequency of flights; conversely, for a fixed frequency of flights, the number of aircraft required to service the network increases as the connectivity of the network increases. If the number of aircraft and frequency of flights are fixed, then load factors will be higher in the hub-and-spoke arrangement.

Gordon and de Neufville (ref. 14) developed a network model based upon the concept of schedule delay, D , which is a measure of frequency of service. The objective is to minimize D on all i routes in a network through appropriate assignment of the number of aircraft, N_i , to each route. Thus, N_i is their only decision variable.

This is a legitimate problem when the regulatory environment is as rigid as it was during the late 60's and early 70's. At that time, the airline routes were pretty well fixed. The type of aircraft were fixed. About the only variable that an airline had at its disposal to manipulate to give it a service advantage over its competition was frequency of service, determined, of course, by the number of aircraft assigned to a route. Stated mathematically, their problem was

$$\begin{aligned}
 \min D &= a \sum_i v_i (1 - p_i^s)^{-1/s} N_i^{-1}, \\
 \text{subject to} \quad & \sum N_i c_i \leq S,
 \end{aligned}
 \tag{1.1}$$

where a = proportionality constant,

v_i = volume of passengers along a link or route i

p_i = load factor along link i , $0 \leq p_i < 1$

c = aircraft capacity in terms of seats,

t_i = distance of link i ,

S = total capability of the aircraft fleet in terms of seat-miles in a given day, and

s = undetermined constant, usually picked to be 1.

The model assumes (1) the line-haul time is relatively fixed, (2) the delay in the movement of any item through the transportation network is an important element in its level of service, (3) delays occur at the nodes of the network and are independent, (4) demand is stochastic and therefore load factors are stochastic as well, and (5) the level of investment capital is fixed, fixing the number of aircraft.

Implications for network shape and aircraft size which are derived from solving this optimization problem are of interest. The analysis suggests that the network which minimizes schedule delay is often, but not always, the one with the smallest number of links connecting all points. Further, it shows that, as a given network becomes more saturated (i.e., as load factors are increased), the network should become more highly connected in order to minimize delay D . The analysis also shows that when there are many parallel links that are possible between two groups of cities, schedule delay is minimized when the number of such links is reduced to one, and one city in each group acts as a hub. Also, it must be recognized that low connectivity networks will necessarily require more tonne-kilometers -- some of the traffic that could be routed directly on more connected networks has to be detoured on the other. Thus for low connectivity networks, both load factors and tonne-kilometers are higher than for high connectivity networks serving the same geographic area.

In terms of aircraft, the model shows that the immediate effect of introducing larger aircraft on the network is, in general, to increase delays, assuming the capital investment in aircraft remains fixed. A concurrent, effect of larger aircraft is to increase the desirability of less-connected networks for any given level of traffic.

Two types of networks were compared using the Gordon and de Neufville model -- the so-called hub-spoke networks (that form minimal edge networks) and networks with more direct service. As expected, the results show that

hub-spoke networks are preferable for minimizing total schedule delay D . This is because there are fewer routes to service and therefore more aircraft are available per route. The increased number of aircraft available per link diminishes total schedule delay D because $D \approx f(1/N_i)$ -- that is, D is inversely proportional to the number of aircraft per link N_i .

Another consideration is that of cargo connections at the nodes of the network. The more numerous the aircraft and flights, the more opportunities there are to schedule connecting flights.

Finally, to minimize schedule delay D , the model shows that the number of aircraft allocated to a link is a direct function of the volume of traffic, vehicle size (number of seats or cargo capacity), and length of trip, roughly according to

$$N_i = \frac{v_i}{c} + K \sqrt{\frac{v_i}{t_i}}, \text{ where } K = \frac{S - \sum_i v_i t_i}{c \sum_i \sqrt{v_i t_i}}, \quad (1.2)$$

which requires that load factors p_i be greater for longer trips and in denser markets. The expression above is the closed-form solution to the problem expressed by Equation (1.1) for $s = 1$.

In this context, the concept of optimal connectivity takes on meaning in the sense that the total network schedule delay may not be the overall optimum if there is a high volume route that would consequently have to connect with other flights through a hub. In this case, that cargo might most appropriately be linked directly (in terms of origin-destination pairs). Thus low connectivity networks require more transfers and handling of cargo, whereas high connectivity networks greatly diminish the number of available flights. An optimal tradeoff between these two extremes is required.

1.2.3. Toward a Network and Network Design Procedure

Formal networks are proposed for both the domestic and the international settings which incorporate these concerns. These are presented in Figures 1.20, 1.21, 1.22, and 1.23 on the following pages. Figure 1.20 exhibits the domestic trunking network illustrating the necessary total connectivity among domestic hubs. Figure 1.21 illustrates the domestic regional networks which connect the various spoke terminals with each hub. Figures 1.20 and 1.21 represent the minimal edge network required to connect all nodes shown on the network. To accommodate heavy traffic routes, the direct network shown in Figure 1.22 is superimposed upon the minimum edge network shown in Figures 1.20 and 1.21. The direct network allows for better service between paired cities experiencing heavy traffic volume. It is estimated that roughly 50% of the domestic freight will fly nonstop with this network, 25% of the freight will require one transfer, and 25% of the freight (by weight) will require two transfers. No freight will ever require more than two transfers while it is in the possession of the air carrier; however, two additional transfers will generally be required to deliver it door-to-door.

Figure 1.23 exhibits what is considered in ref. 15 to be the necessary route structure between international hubs. In addition to the three domestic hubs previously chosen, the international network requires hubs cited in Columbia, Japan, Malaysia, Europe, South Africa, Middle East, and the Soviet Union.

At least as important as the networks proposed here is the methodology by which they were arrived at. The steps of our method are discussed below:

- 1) Use central place theory to locate the nodes of the network -- i.e., the hubs and spokes.
- 2) Connect the hubs with a network of edges of maximal connectivity.
- 3) Connect the spoke nodes to their respective hubs, where each spoke node is associated with the hub closest to it.
- 4) Study the demand volume between city-pairs and connect by means of direct links those city-pairs with the heaviest demand volume. (Those city-pairs whose aggregate demand volume represented 50% were connected in this design).

The approach is evidently quite heuristic and should be contrasted with more formal optimizing approaches that could be used. Even for an optimization problem involving network design (edge determination) alone, the dimensionality of the combinatorial problem is still quite high. The literature suggests that heuristic design schemes hold more promise than do optimizing ones. In any case computer-assisted approaches, if used at all, have their outputs modified strongly before being placed into service (refs. 10, 11, 12).

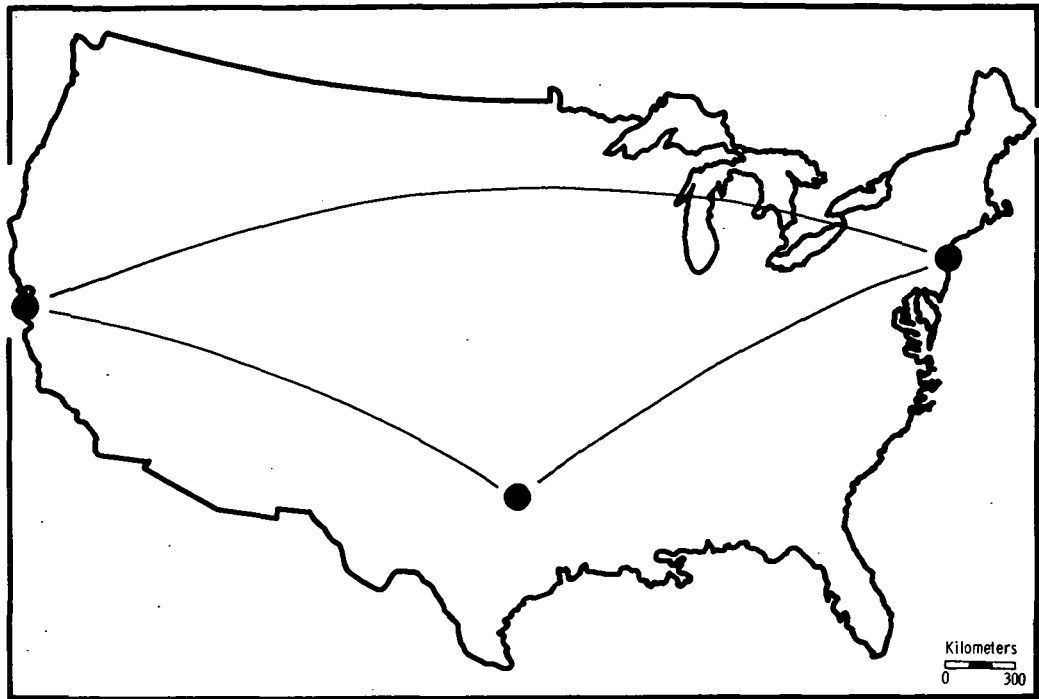


Figure 1.20 DOMESTIC TRUNKING NETWORK BETWEEN HUBS

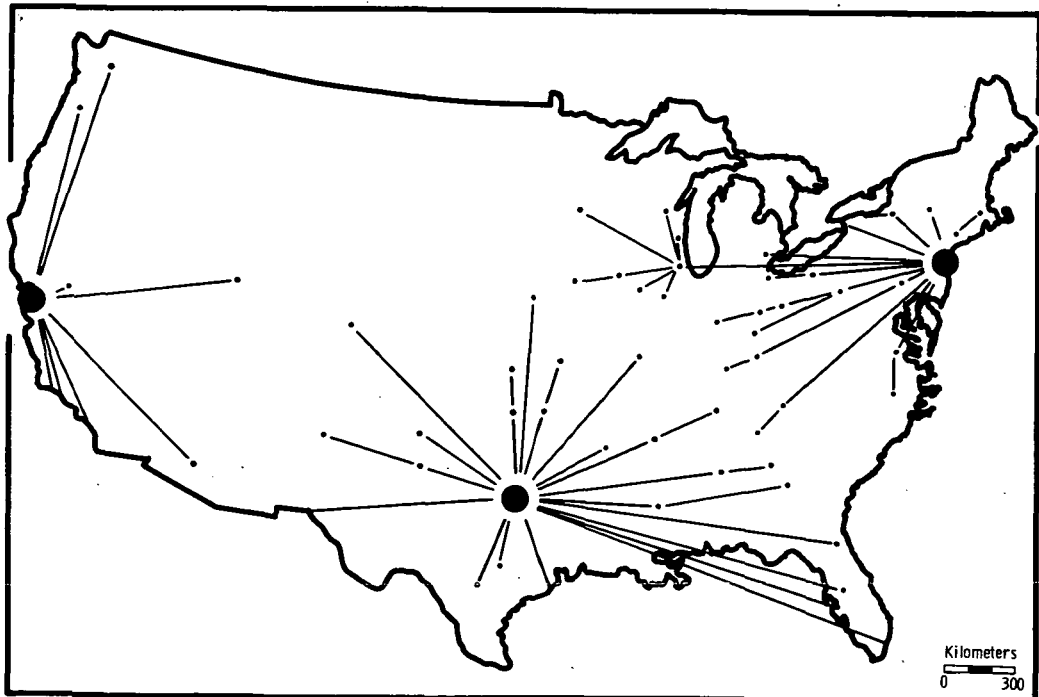


Figure 1.21 DOMESTIC REGIONAL NETWORK CONNECTING SPOKE TERMINALS WITH EACH HUB

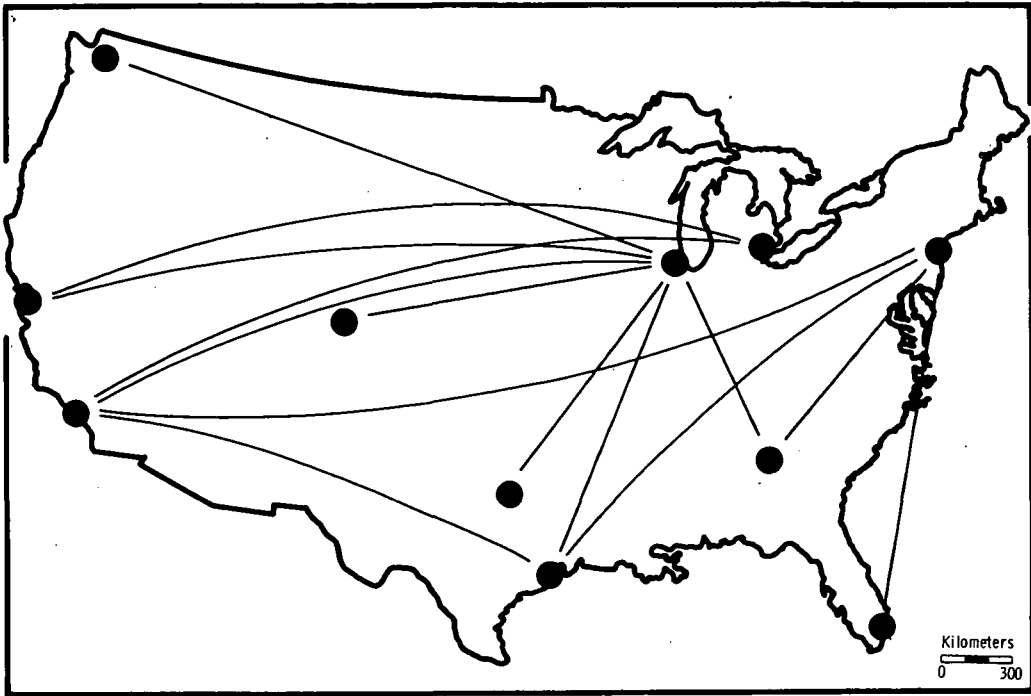


Figure 1.22 DOMESTIC DIRECT NETWORK CONNECTING CITY-PAIRS WITH HEAVY TRAFFIC

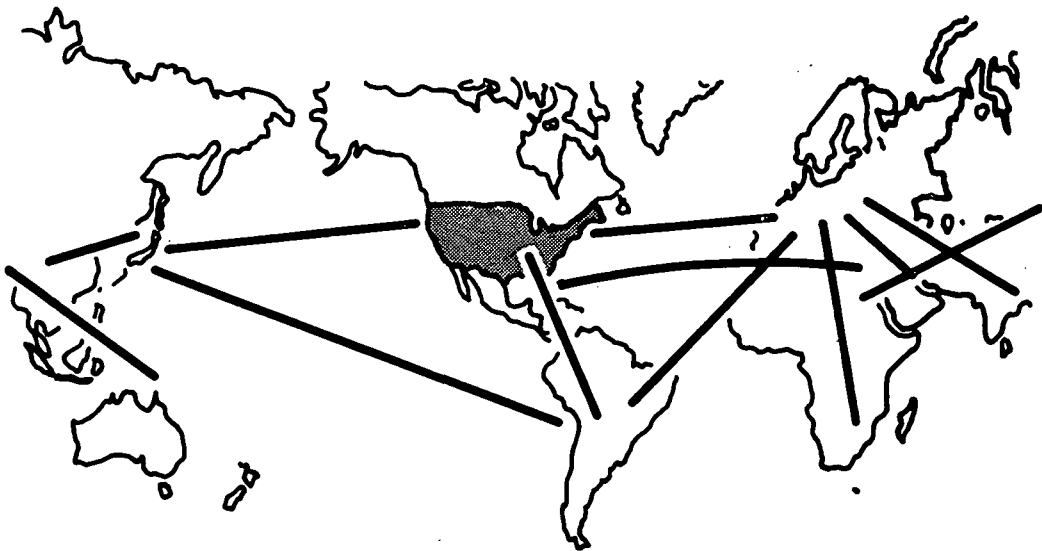


Figure 1.23 INTERNATIONAL NETWORK SHOWING ROUTES BETWEEN HUBS

1.2.4. Scheduling Considerations

Scheduling refers to the manner in which an existing or proposed aircraft fleet is assigned to a predetermined network. There are, according to Pollack (ref. 11), two ways in which heuristic scheduling can be accomplished; however, only one of these is at all practical. The practical scheme described by Pollack is discussed later in this section, as is one optimizing scheme. The scheduling problem has two principal components -- route or cycle determination and frequency of service. The scheduler must decide what aircraft will fly which routes and how frequently each route will be flown.

The two heuristic approaches which could be employed are described briefly here. In the first method, one assumes the fleet sizes are given and the problem is to determine the best possible flight departure times. This method is very complex and is not treated in any of the published literature. In the second method, one begins by specifying a departure range for each flight. The problem is to determine the actual departures such that fleet sizes are minimum. This is the method that will be discussed later.

According to Glenn (ref. 12) an air carrier schedule is a compromise which must consider the interests of many parties as shown in Figure 1.23 (the abbreviation AFC refers to Air Freight Carrier).

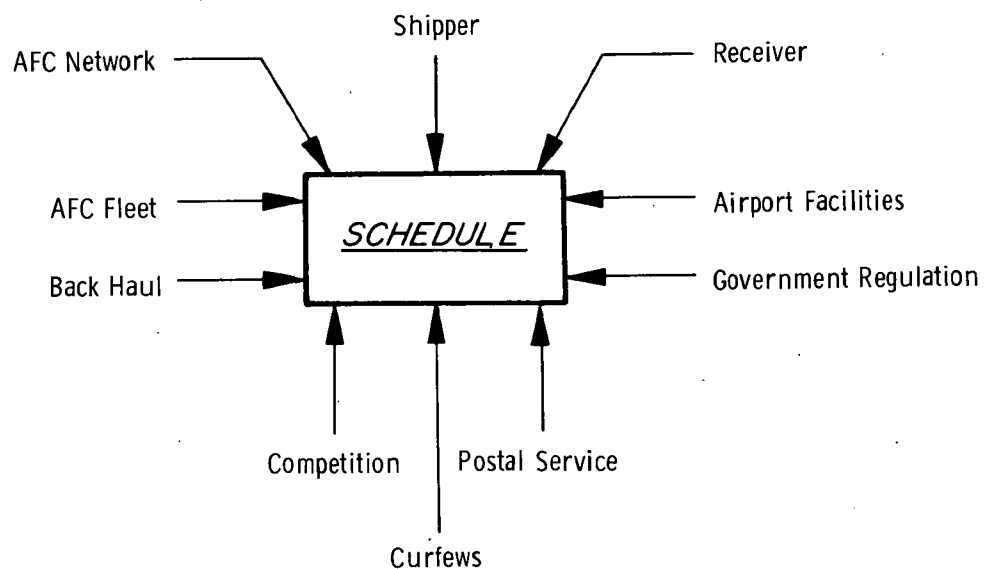


Figure 1.24 FACTORS WHICH AFFECT AN AIR FRIEGHT CARRIER'S SCHEDULE

In addition to the factors listed above, still other factors enter into the scheduling problem, including:

1. aircraft operational conditions and restraints (no two aircraft types are alike),
2. integer variables,
3. seasonal demand,
4. station restraints,
5. marketing continuity
6. nonlinear revenues,
7. nonlinear costs,
8. fixed and variable costs,
9. major (non-aircraft) cost expenditures, and
10. route authorities

Some of these factors are treated in ref. 10. The implication of these myriad considerations is that computer-assisted scheduling has enjoyed only limited success in the airline industry as pointed out by Glenn (ref. 12).

From this extensive list of factors, this discussion will treat only three important topics -- the AFC network, the problem of backhaul, and fleet size. The shipper's concerns relative to scheduling were dealt with previously. Discussions of the remaining considerations are found in refs. 10, 11, and 12.

It is important to include as well the scheduling concerns of those freight carriers in the air cargo system that are not dedicated air freight carriers --namely, the trucking forwarders, and the use of belly space to transport freight on the air passenger carriers. It is assumed here that scheduling of air passenger carriers will be accomplished without significant consideration being given to cargo. And trucking schedules will be determined after dedicated air cargo schedules are established.

The effect which the AFC network has upon scheduling was also considered in the previous section. That discussion is summarized by stating simply that as the connectivity of the network goes up, the frequency of flights must go down and conversely for a fixed capital investment in aircraft. In addition, an increase in connectivity causes decreases in tonne-kilometers and load factors for a fixed capital investment in aircraft.

1.2.4.1. Backhaul

Backhaul refers to loading imbalances that are either characteristic or periodic on certain routes. An aircraft may be almost fully loaded along certain directional links and nearly empty along others. The problem is partially solvable through judicious selection of (1) aircraft size, (2) routing design, (3) frequency of service, (4) real-time rescheduling or reassignment. The backhaul problem is treated in ref. 15 from a scheduling viewpoint. References 15 and 16 provide excellent analyses of the hub and wheel scheduling problem taken in the context of trucking.

However, the backhaul problem also has implications for marketing as well. At each node where serious imbalances exist, the air freight carrier must attempt, through legitimate marketing strategies, to solicit air-eligible cargo that is currently being transported by surface transport systems. Briefly summarized, air-eligible cargo is containerized cargo (as opposed to bulk cargo). More on the subject of marketing is discussed elsewhere in this report.

1.2.4.2. Fleet Planning

Glenn (ref. 12) illustrates the enhanced profitability that can come from the use of smaller aircraft flying more frequently and making fewer stops on routes where demand is not high. In fact, Glenn cautions against the use of aircraft that are too large. Large aircraft may be less profitable for the following reasons:

1. "additional expenses are incurred with the large airplane when it is stopped unnecessarily, and
2. the fleet size relative to the airplane size is more attractive with the smaller airplane, because of increased frequency and opportunities for direct routing."

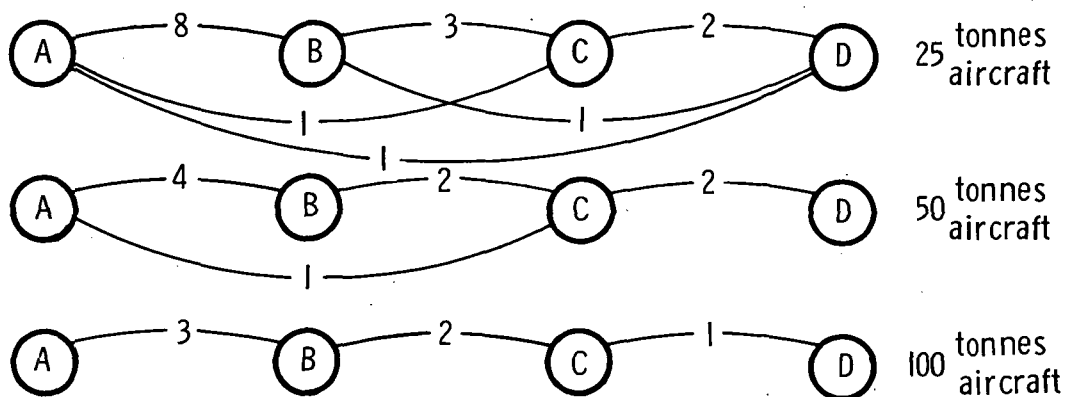
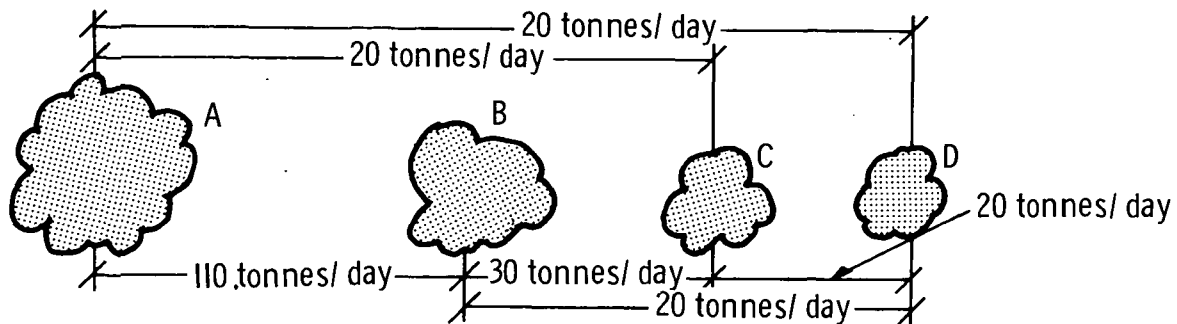
These points are illustrated by the example shown in Figure 1.25 (adapted from ref. 12). In this example, there are four population centers located roughly 320 kilometers apart and roughly in line.

For the network shown in Fig. 1.25, small aircraft provide many direct flights, whereas large aircraft require many intervening stops. As shown, the smallest aircraft is the most profitable for this network. In Glenn's experience, the long-haul flights are most profitable than the short-haul flights, so that it is desirable to not destroy the profitability of the long-haul by carrying it on a series of short-haul route segments. Finally, the increased amount of direct routing possible with the smaller aircraft provides better service to the shipper because of the diminished probabilities of loss, pilferage, or damage due to handling and because of possible diminished schedule delay as discussed previously.

1.2.5. Scheduling Design Procedures

In this section, several schemes for schedule determination are discussed. The first of these schemes is taken from ref. 11 and is heuristic. In this method, one specifies a departure range for each flight and then determines the actual departures such that the fleet size is a minimum.

It is also assumed that the complete set of all flights is given, including the aircraft type, the itinerary, the block, and through times. (Block time is the sum of flight-time and taxi-time between cities. Through time is the time the aircraft is parked at the terminals.) Assuming each aircraft is capable of 9.5 block hours per day, it is possible to estimate the fleet size required by the frequency plan. Since departure ranges are specified in terms



Airplane Size	25	50	100
Fleet Size	3	2	1
Daily Utilization (HRS)	9.1	7.2	9.0
Av. Stage Length	250	222	200
Revenue - \$	3.0M	3.0M	3.0M
Cost - \$	2.7M	3.8M	4.8M
Op. Profit (Loss) - \$	0.3M	(0.8M)	(1.8M)

Figure 1.25 ECONOMICS OF AIRCRAFT SIZE FOR A TYPICAL NETWORK

of a triplet consisting of minimum, preferred, and maximum for departure times, the problem is to select a good triplet for each flight and to determine the minimum active fleet size required to undertake the flights.

The actual schedule construction process is iterative in nature, where each iteration consists of four steps. (1) A triplet of departure times is assigned to each flight. (2) The flights that are compatible in the sense of requiring comparably sized aircraft are linked to form a minimal number of strings (each string corresponds to the set of flights assigned to one aircraft for one schedule period). (3) The cycle diagram is constructed for each aircraft type (the cycle diagram represents the sequence of strings that one aircraft undertakes on successive days or weeks). (4) The total result is evaluated, changes are made to certain parameters, and the process is repeated.

The procedure is predicated upon the following propositions. Initially, each string of flights consists of a single flight with one aircraft assigned to it. Since an aircraft is required for each string, the objective is to form the smallest number of strings. This is done by linking flights together at each city. In this method, the number of unlinked arriving flights is always equal to the number of unlinked departing flights at each city. By linking arriving flights to departing flights, an optimal fleet solution results.

The procedure consists of three phases. Using the preferred departure times, each unlinked arriving flight is linked to the closest unlinked departing flight at each city in the first phase. In the second phase, the actual departures are allowed to shift for those flights that are unlinked at a city. An unlinked pair is picked and the arriving flight is shifted backward as far as possible, while the departing flight is shifted forward as far as possible. If the respective times are in proper relationship to each other, the pair is linked. For flights which have previously been linked, the entire string must sometimes be shifted. The second phase terminates when all unlinked pairs have been chosen and no further linkages are possible.

In the third phase, a city is selected and every linkage is broken at this city. The linking procedure in phase two is then reapplied. This may result in more or fewer linkages being formed at the city in question. If fewer, then the original linkages are restored.

This heuristic procedure works better when the shift ranges are small. Since some loss in utility or performance results from not departing at the preferred departure times, it is desirable to keep each actual departure time as close as possible to the preferred time. A good criterion is a minimum for the sum of squares of the deviations, where a deviation is the difference between the actual and preferred departure time.

Next the flight scheduling problem is formulated as an optimization problem. Let there be M different types of flights to be performed and A aircraft available. Flight type j ($j = 1, \dots, M$) takes time w_j and must be performed r_j times. The intent is to allocate flights to aircraft in such

a way that W (time of completion of the total job) is minimized for a given A . This problem is the inverse of the trim problem. The trim problem is well-known in the operations research literature.

minimize W

$x \in X$

subject to $\sum_{j=1}^M x_{ij} w_j \leq W$ for $i=1, \dots, A$ (1.3)

$\sum_{i=1}^A x_{ij} \geq r_j$ for all $j=1, \dots, M$

$x_{ij} \geq 0$, integer, for $i=1, 2, \dots, A$ and
 $j=1, 2, \dots, M$

Here x_{ij} refers to the number of flights of type i flown by aircraft j and X is the matrix of all x_{ij} 's. The quantity w_j represents the block time required of flight j and the first constraint above insures that no aircraft gets scheduled for more than W time periods. The second constraint above insures that each flight or link gets flown r_j times.

The trim problem is an integer programming problem whose solution would be difficult to obtain in any reasonable amount of computer time for M larger than 40. Also, there may be additional constraints in terms of aircraft assignments to flights. The problem is solvable using cutting plane and branch-and-bound methods discussed in refs. 17 and 18. Of particular applicability is the method due to Balas (ref. 19). In some respects, this model resembles that found in ref. 20. Analogous or related models are described in refs. 21-26.

The inverse trim problem posed above is much easier to solve, as its solution can be approached heuristically. Preston (ref. 20) shows that an optimal solution to the more interesting trim problem can be obtained from the optimal solutions of a sequence of inverse trim problems.

1.2.6. Toward a Feasible Domestic Schedule

For the shipper's interests to be accommodated, what is suggested below is a schedule intended to deliver any airfreight item, which enters the air freight system by 6:00 p.m. local time, before noon the next day if its destination is within the continental United States. For shippers who do not require overnight delivery, a 36-hour service could be provided at a lower cost. We consider first the feasibility of overnight service -- the sort of service which is now being provided by Federal Express.

In most cases, perhaps as many as 90%, it would be possible to deliver before 9:00 a.m. the next day. Consider, for example, an item that must be transported from a site near Olympia, Washington, to a site roughly an hour's drive from Albany, New York. The freight moves first by truck to a spoke airport at Seattle. From there it is transported to San Francisco by feeder aircraft. From San Francisco it proceeds via hub aircraft to New York; from New York it is transported by feeder aircraft to Albany. At Albany it is placed on a truck and taken to its consignee at Schenectady. This is a worst case because the freight is moving from west to east, losing 3 hours (the difference in local times) in the process.

Apparently, this move requires two truck hauls each of one hour duration, two feeder-plane hauls of roughly 1.5 and 0.5 hours duration, and a hub-aircraft long haul of roughly four hours duration. In addition, there are two truck-to-plane transfers and two plane-to-plane transfers, each of which is assumed to take one hour. (Lufthansa unloads and loads its 747's in 45 minutes, ref. 28). The total time required to accomplish this delivery is roughly 12 hours. Add to this the three hours of lost time accruing from west-to-east travel, and it becomes clear that a package placed on a truck in Olympia at 6:00 p.m. can be delivered in Schenectady by 9:00 a.m. the next day.

An appropriate schedule for this case must insure that enough time between the arrival of one leg of the trip and the departure of another leg is allowed to accomplish the transfers. Such a schedule is shown in Table 1.4. In light of this worst-case situation, general guidelines, such as the following, relative to domestic overnight cargo movement can be drawn.

1. Feeder aircraft should arrive at the hub airport not later than 9:30 p.m. for west-coast to east-coast movements. Feeder aircraft should arrive no later than 11:30 p.m. at the southern hub, and no later than 12:30 a.m. at the eastern hub.
2. Hub aircraft must depart no later than 10:30 p.m. for west-coast to east-coast movements. Hub aircraft must depart no later than 12:30 a.m. from the southern hub, and no later than 1:30 a.m. from the eastern hub.

1.2.7. Feeder Aircraft Routing and Scheduling Considerations

The routes flown by the feeder aircraft should be judiciously chosen so as to minimize the fleet size required while maintaining adequate service. It seems appropriate to attempt routing of one aircraft through two hubs. In terms of hub-spoke hexagons, this may be accomplished in several ways as shown in Figure 1.26.

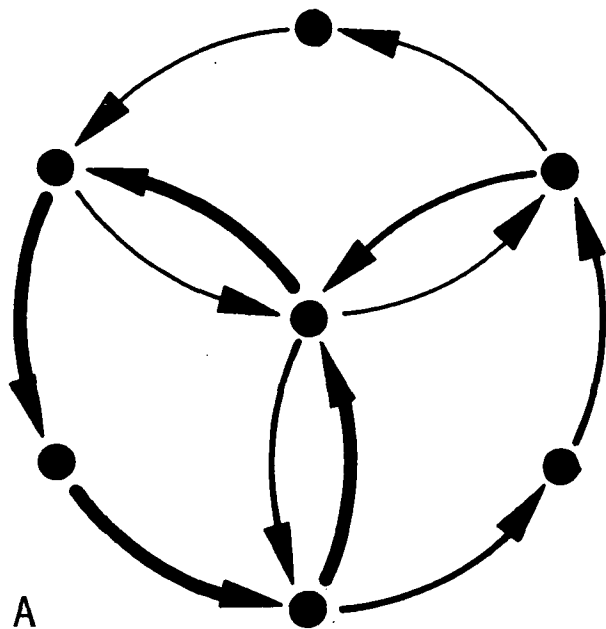
Both routes possess twelve flight legs or four flight legs per aircraft. In some respects, the route network B is preferable because each spoke stop has an intervening hub stop. This would permit complete unloading and reloading at each stop, allowing for the use of smaller aircraft than in network A. However, additional scheduling problems result as it becomes impossible to deliver freight at the spokes in the early morning hours and to pick-up freight in the late afternoon hours, consistent with the needs of the shipper.

In order to achieve efficient utilization of the air cargo facilities (terminals, aircraft, access lanes, etc.), it will be necessary for the air freight carrier to provide incentives (such as lower fares) to encourage the shipper to move his freight at times other than the peak demand period (the early evening hours). If the total demand were distributed more evenly throughout each day, better utilization of the facilities would result and less total capital investment would be required to accommodate those peak periods of demand.

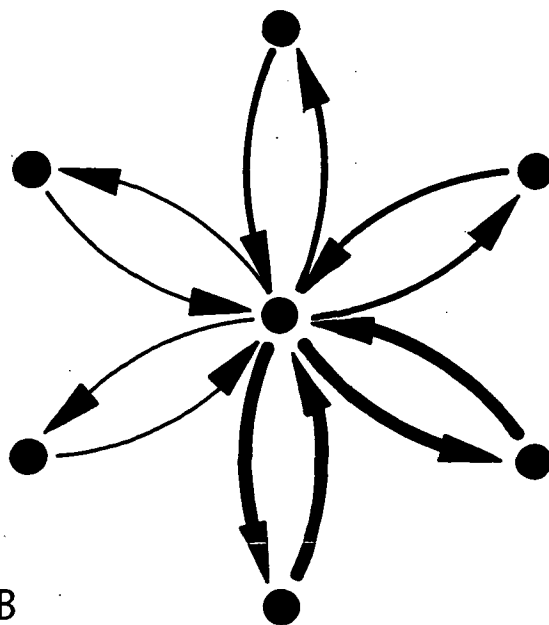
If air cargo demand is seasonal, then dynamic demand scheduling would serve to mitigate this problem by permitting portions of the existing schedule of routes and flights to be changed to accommodate fluctuations in demand. Demand scheduling allows the shipper the opportunity to make a deposit, designate the amount of his shipment and the day the shipment is to be transported about three months in advance. On the day in question, the freight forwarder picks up the shipment, receives the remainder of the transport price, and containerizes the cargo (if it hasn't already been containerized) before delivering it to the air cargo carrier. In this way both the freight forwarder and the cargo carrier can schedule their resources in accordance with demand. If the shipment is not ready on the designated day, the shipper forfeits his deposit and must transmit his shipment at times which suit the convenience of the cargo carrier and freight forwarder. Such an approach would result in generally higher load factors compared to traditional approaches.

A computerized reservation system much like that used for airline passenger travel would have many advantages in this context. First, it would insure that space would be available on the required connecting flights. Second, it would enable the shipper to know each departure and arrival time. Third, it would enable the air freight carrier to utilize dynamic demand scheduling.

The computerized reservation system should have an "intermodal capability". Given the desired departure and arrival times, the system should determine several different transportation plans, each with different levels of service at different fares. Each plan would consist of: (1) the route (and its total cost and time), (2) the links of the route, and (3) the transportation mode



A



B

Figure 1.26 TWO METHODS FOR ROUTING THREE AIRCRAFT OVER A HEXAGON HUB-SPOKE NETWORK

used during each link and the time and cost associated with that link. In this way it would be possible to schedule the entire route required to move the freight from dock to dock. All required links in the move could be reserved, and the reservation system would be free to pick only those modes on which vacancies existed.

1.2.8. Frequency of Service

Since at least some of the cargo must be moved during the day, and in view of the domestic schedule developed in Section 1.2.6., it appears that departure times can be scheduled around the highest departure frequencies of the passenger carriers at the airports where both passenger and dedicated freight flights are arriving and departing. This is depicted in Figure 1.27.

Current and projected air cargo demand indicates that as many as six separate daily flights of hub aircraft may be required to handle the heaviest direct routes between city pairs.* Specifically, for one of the heaviest routes -- Los Angeles (LAX) to New York City -- roughly six flights per day on the average will be required to accommodate the projected cargo volume in 1990. This number split among several (say 3 to 5) competitive air freight carriers becomes quite reasonable. It is anticipated that there would be roughly two departing flights of hub aircraft in the morning and four departing flights of hub aircraft in the evening around 10:00 p.m. There will, of course, be many other departing and arriving flights at LAX but certainly not more than 100 additional all cargo flights. If these flights are scheduled as shown in Figure 1.27, then no additional expansion of the airport capacity would be required. Similar consideration apply to other airports which would transport both passengers and freight.

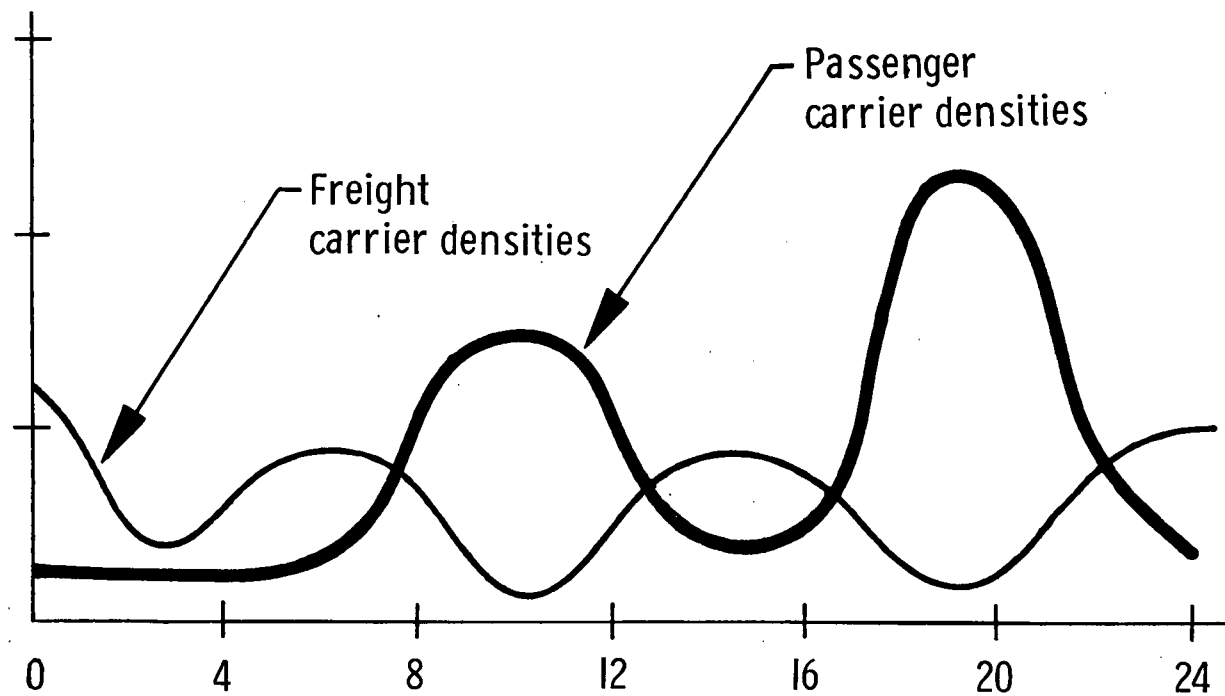


Figure 1.27 RELATIONSHIP OF PASSENGER CARRIER ARRIVAL AND DEPARTURE DENSITIES TO FREIGHT CARRIER ARRIVAL AND DEPARTURE DENSITIES

1.3 ECONOMICS OF NETWORKS

1.3.1. Factors Influencing the Economics of Networks

The number of parameters involved in the study of the economics of any transportation network is tremendous. To complicate the situation, many of the parameters are not independent; that is, changing one parameter to determine its influence on the network also automatically causes a change in some other parameter, thus disguising the desired results. Even so, studies in which parameter variations are made will indicate trends useful in network planning.

If the air cargo system is to offer door-to-door pickup and delivery using various modes of transportation, the following considerations might be included in an economic study. Some of these are much more influential than others in determining the economic stability of the system.

- a. Demand - The requirements for shipping cargo vary from season to season and from city pair to city pair, affecting service, rate structures, and transportation requirements.
- b. Currency Value - The cost statistics for economic analyses will quite often be formulated over several years. Since the value of the dollar varies yearly, the figures must be weighted to allow comparability.
- c. Mix of Transportation Modes - The number of vehicles making up each mode of transportation will influence frequency of service and scheduling as well as investment costs.
- d. Route system - Terminal locations and the routes connecting them are of prime importance in cost analyses (See Section 1.2).
- e. Frequency of Service - User demand and shipper rates will depend on how often a mode of transportation arrives at and departs from a terminal (See Section 1.2).
- f. Freight Density for Each Mode of Transportation - All modes of transportation will have limits on shipments, both in volume and in weight, but different modes are affected in different ways by cargo density. Ideally, each shipment will have the optimal density for the mode used; actually, the loads will be either smaller, lighter, or both. Thus, the full potential of the transportation mode will not be utilized resulting in higher costs per unit volume or unit weight.
- g. Types of Cargo - Certain cargo, such as hazardous materials, live animals, perishable goods, and outsized items may require special handling. This would warrant special rates.

- h. The Backhaul Problem - This problem occurs when any container or mode of transportation is utilized for only one-half of a round trip (see Section 1.2).
- i. Balance in the Use of the Modes of Transportation - Any program analyzing network economics must insure that vehicles in any transportation mode that arrive at a terminal also depart from that terminal.
- j. Location of Consolidation and Break-Bulk Facilities - If these facilities are not located at the transportation terminals, additional links in the hub-spoke system must be added, thereby increasing costs and delays.
- k. Reservations and Sales Costs - Selling and reserving space on a particular mode of transportation for special size or quantity shipments will be a part of the services offered.
- l. Advertising and Publicity Costs - To encourage maximum utilization, businesses and the public will have to be made aware of the services rendered by the air cargo system.
- m. Administrative Costs - These are the costs related to the personnel and equipment required to make the system function.
- n. Transportation Rate Structure - Because of competition or its possible role as a public utility, the air cargo system may have rates established by federal regulation rather than by the free market system.
- o. Investment Costs - These include the costs of the modes of transportation, the way, and supporting equipment.
- p. Transportation Mode Operation Costs
 - 1. Direct Operating Costs
 - (a) Fuel and oil
 - (b) Crew or operators
 - (c) Insurance
 - (d) Maintenance labor
 - (e) Maintenance material
 - (f) Maintenance burden
 - (g) Depreciation
 - 2. Indirect Operating Costs
 - (a) Supporting equipment maintenance
 - (b) Supporting equipment maintenance burden
 - (c) Supporting equipment depreciation and amortization

- q. Revenues - The total income from all sources must be accounted for if earnings are to be maximized.
- r. Sub-optimal Performance - Weather or mechanical failures may force a cancellation of shipments or a change in schedules.
- s. The Effect of Competition - Competition tends to force a reduction in rates and must be taken into account in forecasts.
- t. The Atmosphere of Regulation - If the government controls rates and routes, a less cost effective system will result (See Section 3.2).
- u. Shipment Priority - The inclusion of more than one shipment priority will add to the complexity of the system and thus raise costs.

1.3.2. Network Economic Optimization Models

The economic analysis of any type of air cargo network is an extensive problem. Add to this the network requirements of door-to-door pick-up and delivery and the problem is compounded further. The quantity of factors affecting costs is extensive and their level of influence varies from critical to almost negligible.

Simple and complex computer programs have been written by airframe manufacturers, airlines, and government agencies to study network economics; all have their shortcomings. Primary among the problems of a program is the inability to place a correct, if any, value on time. Attempts have been made to equalibrate the value of time to the value of warehouse storage, duplicate inventories, depreciation and obsolescence, and tie-up of capital. Useful as this might be, it still fails to account for human desires and needs, particularly during emergency situations. At such times, the value placed on time may be so high that the cost of shipment, no matter by what means, will be negligible in comparison. While time obviously has value, that value varies widely and can be specified only for specific shipments under specific conditions.

The analytical and algorithmic methods used in determining the most cost effective network are generally classified as optimization and heuristic methods. These procedures may be used either to minimize costs or to maximize earnings. The latter effort is more extensive since earnings may be assumed to equal revenues less costs. Thus, to insure maximum earnings, costs must be minimized and revenues maximized. A brief description of several techniques follows.

The classical transportation problem: This type of linear network optimization is useful primarily for the planning of the physical network, i.e., route determination. Its goal is to minimize total transportation cost.

The mathematical description of this problem (ref. 29) is

$$\text{minimize} \quad \sum_{i=1}^m \sum_{j=1}^n c_{ij} x_{ij} \quad (1.4)$$

in which c_{ij} is the shipping cost per tonne from point i to point j and x_{ij} is the number of tonnes shipped from point i to point j . The model restrictions are stated as

$$\sum_{j=1}^n x_{ij} \leq S_i \quad i = 1, 2, \dots, m \quad (1.5)$$

indicating the supply limitations on the number of tonnes shipped,

$$\sum_{i=1}^m x_{ij} \geq D_j \quad j = 1, 2, \dots, n \quad (1.6)$$

indicating the demand limitations on the number of tonnes shipped, and

$$x_{ij} \geq 0 \quad \text{for all } i \text{ and } j \quad (1.7)$$

implying that no negative quantities may be shipped. If the total supply is at least as large as the total demand, it is always possible to find a feasible transportation network in which no more than $(m + n - 1)$ routes are utilized and an optimal solution in which no more than $(m + n - 1)$ routes are employed.

Application of this technique to the hub-spoke system proposed in Section 1.1 would be most beneficial to the pickup and distribution of freight in the spoke regions. The remaining network routes are established from the selection of hub and spoke terminals.

Linear programming: A combination of analytical and graphical procedures may be used to determine which modes of transportation should be used for the various links of the network as well as how long these links should be. The requirements for using this technique are that the equations of cost for the various modes of transportation be linear and constraints be indicated in the form of equalities or inequalities (ref. 30).

An example of the analysis of a hub-spoke system, based upon the central-place theory discussed in section 1.1, follows. In this example, the cost is minimized with respect to the distances through which the various modes of transportation will move the cargo. It is assumed that one unit of cargo, which is evenly distributed throughout the region served by hub A, is transported to the region served by hub B and evenly distributed throughout it (Fig. 1.28).

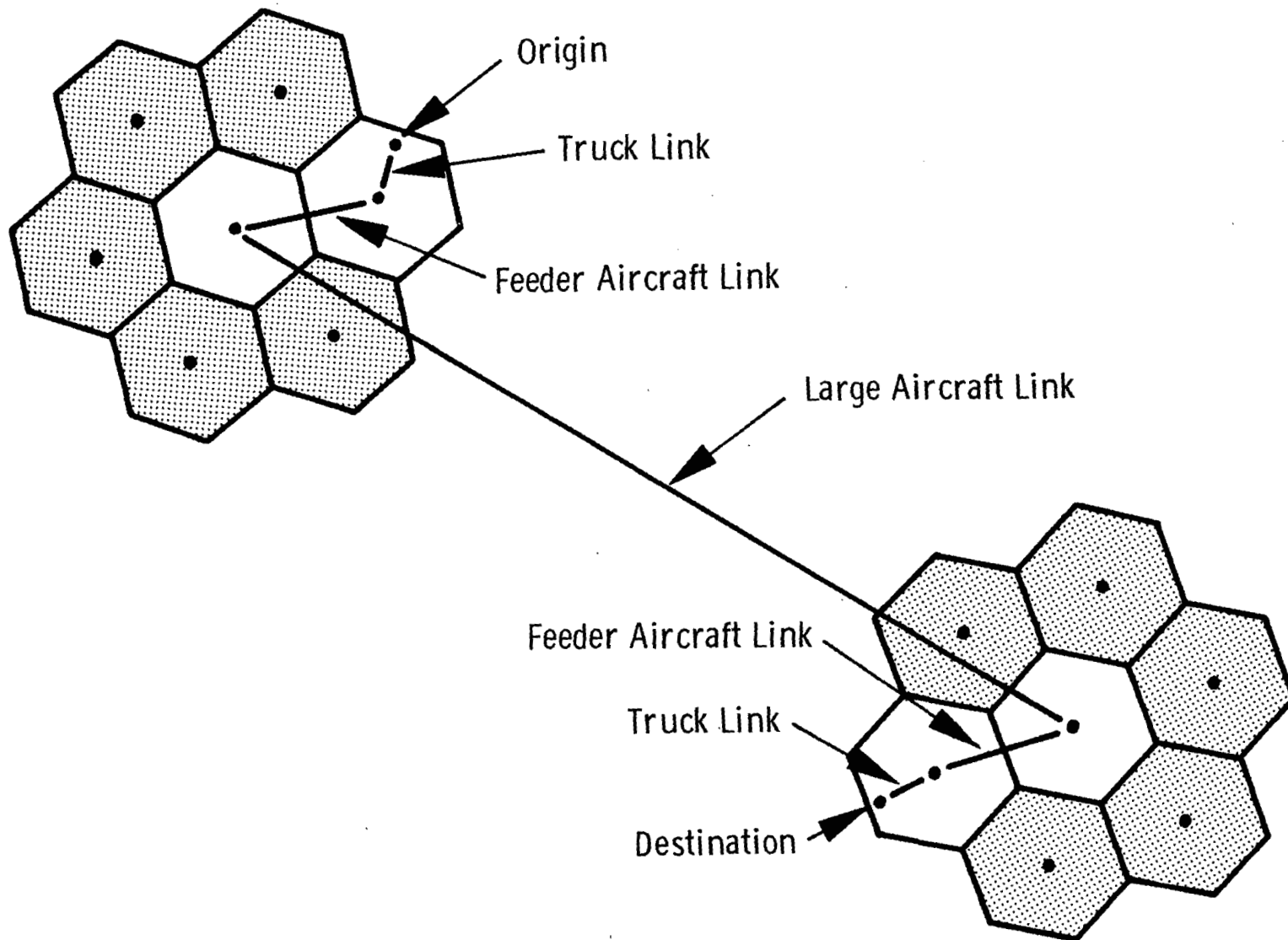


Figure 1.28 THEORETICAL HUB-SPOKE

Further restrictions or constraints include:

- a. The pick-up and transport to a spoke terminal and the delivery from a spoke terminal to the destination is handled by truck. From the CLASS report (ref. 31), these vehicles have total operating costs given by

$$C_T = \frac{2}{25} R_T + 60 \quad (1.8)$$

where C_T is the cost of shipping by truck and R_T is the distance traveled. The maximum range is considered to be 550km (340mi). The constant (60 for truck) is the minimum fixed cost characteristic of a single trip by the vehicle.

- b. The transportation between spoke and hub terminals is by intermediate-payload freight aircraft having a maximum range of 2400km (1500mi) and a cost curve estimated to be

$$C_F = \frac{4}{25} R_F + 170 \quad (1.9)$$

in which C_F is the cost of shipping by feeder aircraft and R_F is the distance traveled. The minimum range is assumed to be 1100km (685mi), an arbitrary choice determined by the point at which the line haul costs are equal to the sum of the remaining costs.

- c. The transportation between hub terminals is by long-range, high-payload freight aircraft having a cost curve of (ref. 31)

$$C_L = \frac{3}{25} R_L + 170 \quad (1.10)$$

where C_L is the cost of shipping by long range aircraft and R_L is the distance of shipment. This aircraft is assumed to have a maximum range of 6400km (4000mi) and minimum range of 1400km (870mi), for the same reason as indicated for the feeder aircraft.

- d. The total trip length is 8000km (5000mi).

These transportation costs and constraints may be stated analytically as

$$\begin{aligned} \text{total cost} = C &= 2C_T + 2 \left(\frac{6}{7}\right)^* C_F + C_L \\ &= 2 \left(\frac{2}{25} R_T + 60\right) + 2 \left(\frac{6}{7}\right) \left(\frac{4}{25} R_F + 170\right) + \frac{3}{25} R_L + 170 \end{aligned} \quad (1.11)$$

$$= \frac{4}{25} R_T + \frac{48}{175} R_F + \frac{3}{25} R_L + \frac{4070}{7} \quad (1.12)$$

subject to the constraints:

$$2R_T + 2R_F + R_L = 8000 \quad (1.13)$$

$$0 \leq R_T \leq 550 \quad (1.14)$$

$$1100 \leq R_F \leq 2400 \quad (1.15)$$

$$1400 \leq R_L \leq 6400 \quad (1.16)$$

Solving equation (1.13) for R_L and substituting into equation (1.12) yields

$$C = \frac{-2}{25} R_T + \frac{6}{175} R_F + \frac{10790}{7} \quad (1.17)$$

Since the cost is now expressed as a function of R_T and R_F , graphical procedures may be used to find the minimum cost, as illustrated in Figure 1.29.

The dashed lines representing solutions of constant cost, obtained from equation (1.17), indicate a minimum cost of \$1535.14, occurring when $R_T = 550\text{km}$ (340mi), $R_F = 1100\text{km}$ (685mi), and $R_L = 4700\text{km}$ (2900mi). This solution is compatible with the hub-spoke system based upon the central-place theory.

If the same basic problem were solved with the constraints on the truck and feeder aircraft changed to

$$0 \leq R_T \leq 1000 \quad (1.18)$$

$$0 \leq R_F \leq 2400 \quad (1.19)$$

the minimum cost would be \$1461.43 occurring when $R_T = 1000\text{km}$ (620mi), $R_F = 0\text{km}$, and $R_L = 6000\text{km}$ (3700mi). The savings over the previous example would be \$73.71.

This is only a 4.8% decrease in price in conjunction with a probable two-day delay in transit due to the elimination of the feeder aircraft as a mode of transportation and the lengthening of the truck link. Whitehead (ref. 24) obtained a similar result. Weakness in this model and Whitehead's is the failure to place a value on time.

*Only six of the seven hexagons in the hub region (See Fig. 1.26) are served by feeder aircraft.

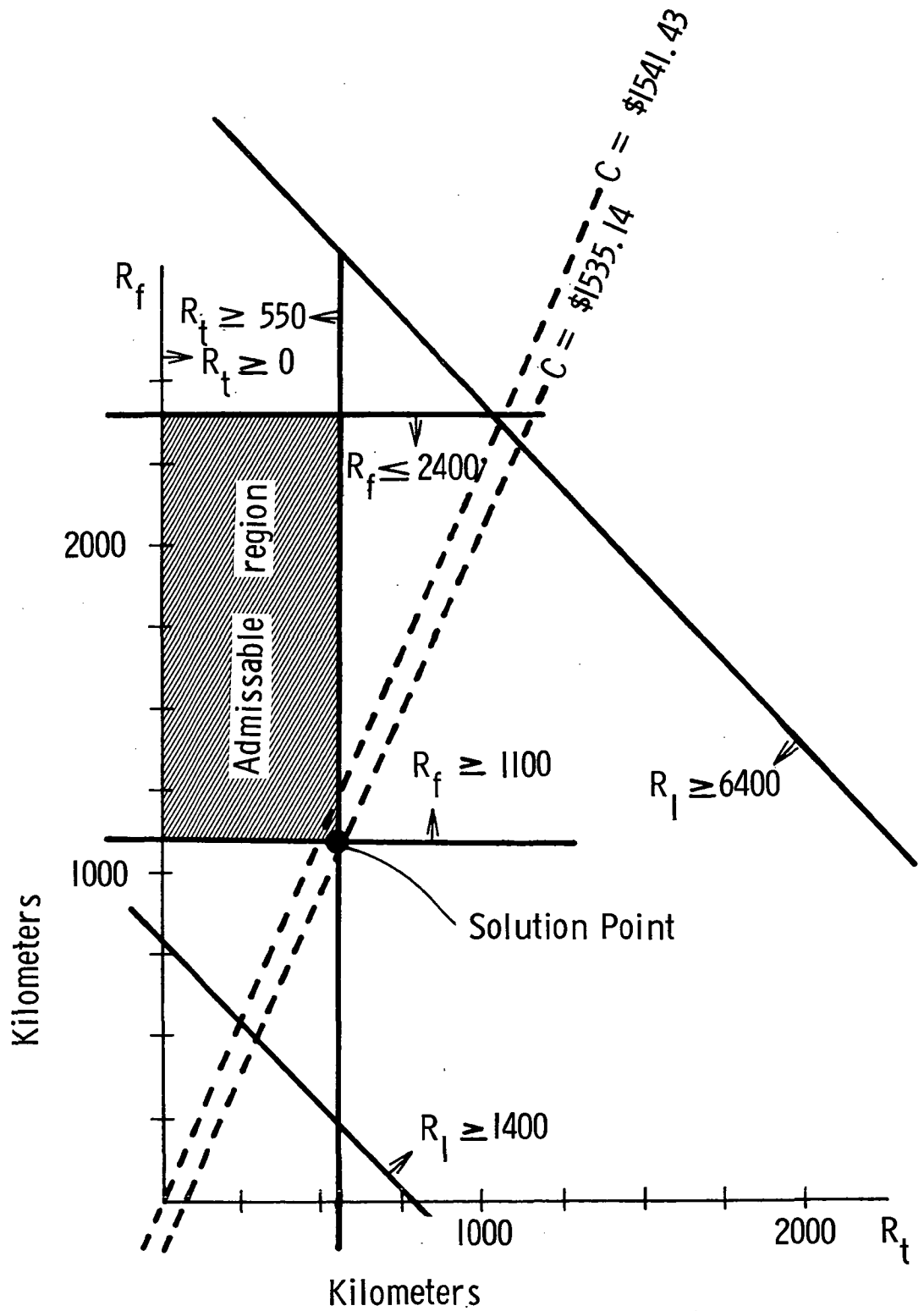


Figure 1.29 LINEAR PROGRAM SOLUTION

If an arbitrary value on time were set at \$480 per unit load per day, the shipping costs in the last example would rise by \$960 to \$2421.43. This is a 65% increase over the cost when the feeder aircraft is used and a 57.7% increase over the cost of the first linear programming example where the more restricted range constraints were imposed. Thus, the usefulness of assigning time a value is illustrated as is the need for feeder aircraft in the hub-spoke system.

A second approach to placing a value on time is to introduce a cost per unit time value into the cost equations for each mode of transportation. If this value were set at \$20 per unit load per hour, the equations of cost for the three modes of transportation would become

$$C_T = 20 \left(\frac{1}{88.5} \right) R_T + \frac{2}{25} R_T + 60 \quad (1.20)$$

in which 88.5 is the average speed in km/h (55mi/hr) for trucks,

$$C_F = 20 \left(\frac{1}{88.5} \right) R_F + \frac{4}{25} R_F + 170 \quad (1.21)$$

where 885 is the average speed in km/h (550mi/hr) of the feeder aircraft, and

$$C_L = 20 \left(\frac{1}{950} \right) R_L + \frac{3}{25} R_L + 170 \quad (1.22)$$

In this last equation, the 950 represents the average speed in km/h of the long haul aircraft (590mi/hr).

Substitution of equations (1.20), (1.21), and (1.22) into equation (1.11), using the constraints indicated in equations (1.13), (1.14), (1.18), and (1.19), and following the graphical procedures outlined above, yields a minimum cost of \$1734.23. This cost occurs when $R_T = 0$ km, $R_F = 800$ km (500mi), and $R_L = 6400$ km (4000mi). This answer, though mathematically correct, is not realistic since it implies that every user will have a feeder aircraft airport at his door. Only by further constraining the minimum range of the feeder aircraft may this pitfall be avoided.

Modified forms of equations (1.20) and (1.21) may also be used to allow the shipper to determine how much his time must be worth to use both truck and feeder aircraft economically for either the first or last two links of the hub-spoke system, as opposed to use of truck only. For this method, the cost of truck transportation from origin to hub terminal (or from hub terminal to destination)

becomes

$$C_T = 60 + \left(\frac{2}{25} + \frac{C}{88.5}\right) D \quad (1.23)$$

in which C is the cost per unit load per hour, a variable, and D is the distance from origin to hub terminal (or hub terminal to destination), also a variable. The cost between the same points using both truck and feeder aircraft becomes

$$C_{T-F} = 170 + \left(\frac{4}{25} + \frac{C}{88.5}\right) (D - D_T) + 60 + \left(\frac{2}{25} + \frac{C}{88.5}\right) D_T \quad (1.24)$$

in which D_T is the distance from the point of origin to the spoke terminal (or from the spoke terminal to the destination). Equating (1.23) and (1.24) yields

$$-\frac{2D}{25} + \frac{9C \cdot D}{885} + \frac{2D_T}{25} - \frac{9C \cdot D_T}{885} = 170 \quad (1.25)$$

For each value of D_T (a parameter), a curve of distance from origin to hub terminal (or hub terminal to destination) versus cost per unit load per hour may be obtained, as shown in Figure 1.30. Thus, if a shipper is, for instance, 1000km (620mi) from the nearest hub terminal and is 300km (190mi) from the regional spoke terminal, his value on time must be at least \$31.61 per unit load per hour before the use of feeder aircraft becomes economical. Values on time of less than \$31.61 per unit load per hour indicate that only trucks should be used.

Gradient methods: Gradient methods or methods of steepest descent or ascent are numerical methods characterized by iterative algorithms for improving the estimates of independent variables so as to satisfy the condition for a maximum or minimum. A complete description is given by Bryson and Ho (ref. 30). These methods would allow an optimal solution if the cost functions for the various modes of transportation were nonlinear and the constraints of the problem were of the equality or inequality type.

1.3.4. Remarks

As has been implied previously, the trade-off between cost and time must constantly be remembered. Though the mathematics of the problem may indicate one solution, the value placed on time by the user of the system must not be forgotten. A theoretical model of a network may be suitable for initial studies, but the analysis of a specific network of routes and terminals and insertion of time cost values will yield more reliable data.

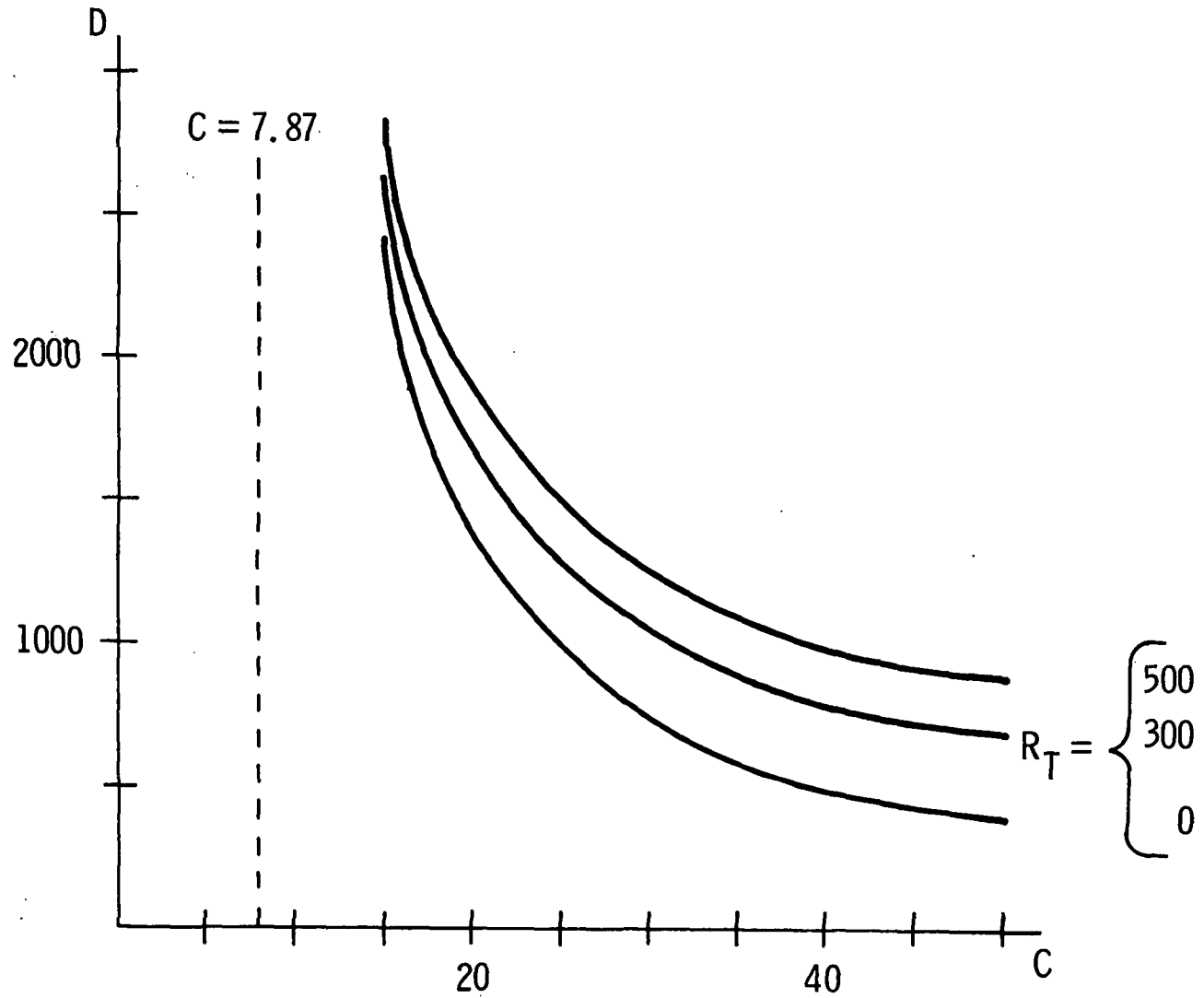


Figure 1.30 THE VALUE OF TIME PER UNIT LOAD PER HOUR

No matter how sophisticated, any economic model which uses the forecasts of future situations is susceptible to error. Major and occasionally minor errors in estimating future demands, capabilities, and operations could negate all results of an economic analysis. As a result, it is not unusual to find that "gut feelings" may reveal trends just as accurately as a complex computer program.

1.4 CURRENT CARGO CAPABILITY AND POTENTIAL

1.4.1. Existing Airports and a New System

A great deal of information on the cargo capabilities of existing airport facilities should be known before any attempt is made to select an optimal set of airports in any coordinated network of air freight delivery. Because they represent, largely, undeveloped regions of the country where expansion is possible and investments exist, the current and idle military air facilities could augment the generally more desirable but constricted civil airports.

Description of airport freight capacity is complicated by the fact that, except for military airfields, there is no airport cargo capacity, but rather a series of cargo capacities, one for each of the airlines or other freight forwarding firms located at the airport. At any one field, the various firms may be almost anywhere on the continuum from passenger service only, through small parcel and major belly cargo carriers, to freight-only firms. Large fields tend to have several large cargo firms, but some smaller firms as well. Smaller fields may be strategically located and have high cargo requirements or have none at all.

The amount of detail desirable for assessing the current and potential value of a given field in the overall air freight system depends also on the basic system philosophy. A few major hub freightports fed by truck have entirely different implications from a multihub system or one that uses a relatively large number of feeder airports with or without major freight hubs.

The network design assumptions may require, say, three U.S. hub air freightports. The constraints on airport capacity could conceivably rule out this design because the locations needed for efficiency could not be modified to handle the projected volume of cargo. An alternative might then be a point-to-point network made up of more feasible cargo capacities at a larger number of airports.

To allow for network design tradeoffs and contingencies, and for the selection of those best suited to the system requirements, an inventory of factors influencing freight capacity of existing air facilities is needed for a relatively large number of airports. No such inventory exists with the kinds of current, detailed description desirable. A preliminary version of a questionnaire which would collect these data is found in Appendix C of this report.

Even if all the desired information were available, of course, there is no authority which can suddenly impose a design on the providers of air service in the U.S. A new system must evolve from its current status to one which meets the needs of the changing world in terms of demand and economics. For a rough notion of the current cargo picture, some information on current airports

is given in Table 1.3.

Before the "ideal" system can be conceived, it is informative to examine the way the present needs are met. In this space age of pocket computers and automated Mars explorations, it may be surprising to discover that much of the air cargo is handled with little beyond 1950 technology. Newer planes are used, and the computer helps in the paperwork, but the progress of mechanization in moving goods has been modest. The next few pages describe what goes on today. After a brief status report, the operation in a moderate-sized airport is described in detail. While a few airports around the world handle much greater volumes, the total moved by all the moderate-sized airports is what makes the whole system work and gives potential for the future.

A brief look at a proposed military air cargo terminal is given next for possible insight. This is followed by a look at what many might have expected was typical -- automatic container handling and storage at a major airport. This section concludes with a discussion of the direction in which our current system is likely to go. The forces which mold evolutionary change are not likely to change in the near future. They include occasional step-wise improvements but are more often incremental improvements on current conditions until fundamental changes are forced on the system. These changes are triggered by growing inefficiencies or daring innovators who threaten the status quo.

1.4.2. Today's "Non-System" of Cargo Service

The U.S. Airlines, all carrying some kind of cargo, operate about 13 000 scheduled flights daily. This amounts to 20 million freight shipments annually involving 600 American airports and 100 foreign airports. In the U.S., over 10 000 communities are served by truck and air. Air freight totals about 3.3 million tons a year, half of it in all-cargo aircraft, the other half in the bellies of B-747, DC-10, and L-1011 passenger aircraft.

The problems in the use of air for cargo arise in the lack of convenient point-to-point delivery service. Brochures discuss the service provided by "some airlines" (ref. 32) but not all. "Often, there are signs at the airport directing shippers to the ticket counters accepting the small packages," but usually not; some charge "a flat fee to move a package anywhere in its system," according to the brochures, others charge according to route segment; pick up or delivery can be arranged by "some airlines" and "there are some provisions for interlining" (pre-arranged transfers among two or more airlines). The exceptions make the system most useful for exchange between major population centers and for emergency shipments where the complexity is acceptable because of urgent need for speed.

Through an organization called Air Cargo, Inc., air carriers in North America have developed a fairly widespread system of delivery by air and truck to small communities. A bi-monthly directory listing these thousands of cities is available. There are 32 certified airlines, 160 motor carriers, and 30 commuter airlines participating in the Air/Truck Programs. Speed and reliability, as well as cost, are likely to vary widely in such a conglomerate which lacks integral coordination of operations.

In contrast, Federal Express Corporation (FEC) was organized in 1973 to offer the same kind of service where speed and reliability of delivery for small packages was the main objective. This single organization of trucks and small aircraft with highly flexible and efficient routing and mostly night flights allows service not possible in a multi-firm cooperative effort. For small shipments (up to 70lb, routinely), FEC has a near monopoly on point-to-point delivery over much of the U.S. Many small communities continue to lack service, but an expanding air cargo demand demonstrates the need for a system. The \$50 million initial capital investment - the largest ever arranged in the U.S. - created a system which started from nothing and turned a profit in only two years. There is little chance that a direct competitor will appear in this market; however, the system of heavy routine and emergency shipments in which air freight is economically feasible constitutes a separate, complementary market which is now being served to some extent but is not being developed to anywhere near its potential.

For efficiency with larger volumes of air cargo, containerization must eventually be developed. This requires not minor improvements, but revolutionary redesigns in facilities and large investments. Whether individual airlines can continue (or will decide to) make these investments or consolidate into airport-wide cargo systems is yet to be decided.

1.4.3. The Air Cargo Complex at Baltimore-Washington International Airport (BWI)

There are 15 certified airlines now serving the cargo needs at BWI and several more are expected in the next few months. Only 25 airports in America have more than BWI (See Table 1.3). It also has 26 air forwarders serving it and only 11 airports exceed this number. This makes BWI a "large" airport, probably typical of the major feeder airports which would make up any future organized cargo network. It is enlightening to discover how freight is now being handled at such a "major feeder".

As in any civilian air terminal, there is really no airport cargo handling system, but only a series of separate, widely divergent airline cargo systems which represent the present cargo shipping practice. The cargo complex at BWI consists of three buildings which are essentially back-to-back docks with a small floor space between them. Trucks back up to one side and unload and, after a sorting process, other trucks back up to the other side to deliver freight to the airlines or airplanes. All packages are in and out in a matter of a few hours, often a few minutes. While there is the usual series of small cargo facilities or offices for each air carrier, separate buildings are used by three major cargo carriers.

In addition to the 15 scheduled cargo-hauling air carriers now serving BWI, several major and smaller freight carriers are said to be considering locating there (ref. 33). These include Iberia, Lufthansa, KLM, Flying Tiger, and others. Piedmont recently moved its entire operation there, and North Central Airlines moved there in August 1978.

The runways at BWI are capable of handling all aircraft including the C-5A which has landed there, but the Concorde and the DC-8-61, for example, should have longer runways for routine operations which involve maximum loads and all weather conditions.

BWI is about fourth in U.S. air freight growth rate, but there are problems in ranking airports. For example, BWI, with 20 795tonnes (22 923tons) of freight enplaned in 1977, ranks about 20th. Yet the freight deplaned at BWI was almost twice as much, 38 570tonnes (42 520tons), and another 20 300tonnes (22 375tons) of mail was enplaned or deplaned (almost equally) in 1977. For capacity analyses, it could be argued that the ranking should be based on the sum of the larger of the cargo enplaned or deplaned plus the larger of the mail enplaned or deplaned. This is more closely related to current operating capacity than other combinations of these figures. Since some airports have greater incoming loads than outgoing loads and others are the opposite, neither figure can be used for overall comparisons. In the same way, totals of incoming and outgoing freight are misleading since an even balance is more efficiently accommodated than unbalanced cargo flows, so a freight flow of 50 units in and 50 units out probably requires less investment and staff than one with 70 units in and 30 units out, even though the total freight handled is 100 units in each case.

National Airport near Washington, D.C., will have a curfew imposed soon, according to its operator, the Federal Aviation Administration. This will tend to make air cargo firms shift to BWI. Several firms have indicated they will make this move, and BWI expects to double cargo volumes in the next few years. Deep water containership ports are 8 to 10 miles away, Conrail comes near a current runway terminus, and the interstate system is easily accessible, making a truly multimodal operation possible. However, airline marketing efforts, with a few exceptions, show little expertise in cargo handling or knowing the customer's needs. The air forwarders are now the biggest customer of the airlines, doing the marketing for them. The forwarders, if they buy planes, could become the biggest competition of airlines. This fact seems to have aroused little anxiety among airline executives.

At BWI, United Airlines Cargo system is the largest of the cargo carriers, and the only one with regular air freighter aircraft. BWI is a major truck terminus for United, gathering freight from Philadelphia, Washington, Norfolk, and Richmond areas since none of these has air freighter service. Two DC-8 freighters leave BWI at 12:30 a.m. and 02:20 a.m. Tuesday through Saturday. Other freight is sent by belly cargo in B-737, B-727, and DC-10 (widebody) passenger flights with belly cargo during the daytime, depending on destination, schedules, and expected freight volumes. The decision as to which plane will carry a package is largely dependent on the cargo agent's knowledge of flight alternatives, rather than a formal routing or decision system. Presumably poorly routed packages would not result in feedback to this agent unless a serious (to the shipper) delay resulted. This system also implies that different agents often make different judgments. While actual routes are documented after a decision for tracing, it seems likely that improvements could be made if it were shown to be desirable.

Cargo can arrive almost anytime of the day or night at the terminal, though the bulk arrives after 4 p.m. and continues to come in until after 11 p.m. About 10 p.m., the container filling begins, with men obtaining empty containers from the storage area outside the plane docks, and moving them in on dollies either by hand or by electric truck. Freight from pallets or loose boxes and crates are stuffed into the containers. Heavy items are moved by forklift truck, but most packages are manually arranged in the containers for the main deck of the DC-8, or the various LD (lower deck) shaped containers for use in the B-747 or DC-10 bellies. This requires the loaders to climb into the container to fill the volumes as they see fit. Each container is loaded with material for one ultimate or intermediate destination.

As each item arrives at the cargo terminal, an airbill is made out showing origin, destination, contents, number of items, weights, and airbill number. Copies of this airbill are attached to the package in an adhesive envelope. As the pallet or container is filled (unitized), the airbill numbers and weights are written on a sheet which will be placed in a cargo pallet tag (envelope) which is attached to the outside of the container with a wire twist. As containers are made up, the content lists are sent to a weight and balance agent who must that the aircraft will fly well as loaded and that the total weight is not excessive. It is usually the volume rather than the weight capacity that limits the load. About 240kg/m^3 (15lb/ft^3) density would be required for just filling both weight and volume limits, and freight often average less than 160kg/m^3 (10lb/ft^3). With the loss of useable volume in the aircraft and empty spaces in containers, the density may drop even further, to 96kg/m^3 (6lb/ft^3) perhaps.

As containers are filled, the order of aircraft loading is determined for weight and balance purposes, and the containers are staged for loading. A mechanized system allows a pallet or container with its dolly to drop into a pit for loading. This pit is also used to fit the cargo nets over pallets for securing the loads. One or two filled units are placed on each of nine motorized roller tables. When the plane is ready, the elevator loader is moved into position at the plane's cargo door and a loader vehicle shuttles each container to the elevator in the required order. The loader vehicle is driven up to one of the nine staging lines, the operator reaches out of the cab window and pushes a button on a switchbox suspended conveniently from a cable. This moves a container to the loader, which is then turned around and driven to the lowered elevator. The container is moved electrically on to the elevator; it is raised, after which the container moves forward to the plane-level platform. The elevator can then be lowered ready for the next container while the one just delivered is moved into the plane and pushed manually into its assigned position. A round trip by the vehicle takes less than 30 seconds.

While the containers are being loaded, electric carts have been busy hauling loose cargo and mail sacks to the fore and aft belly compartments. As the total load becomes known, the pilot may decide to add fuel since the load is estimated, often quite inaccurately, prior to receiving all the outgoing cargo. Fuel is taken on for the estimated load, but excess fuel weight is avoided for economy. The entire loading and aircraft checkout process requires about 30 minutes after the containers are ready. Some containers for other

flights may be moved to the passenger aircraft belly loading areas at any time as well.

Meanwhile, documentation is proceeding in the office and in the cargo area. Information from the airbill is entered into a computer display system for tracing each item. Its location and schedule can be called up in any of United's cargo offices, and the delays in entering information are short since the work progresses as freight is containerized and during loading. The information is transferred manually several times for making up the containers, for the pilot's manifest and the weight and balance calculation, for container labeling, and for the tracing and billing system. Recording errors are fairly common, but redundancies allow resolution with little delay in most cases. Where there are several pieces in one shipment, a stencil is cut and each carton is printed with a hand-held inking device.

One is impressed with the apparent confusion during the loading period and the apparently successful sorting, routing, billing, handling, timing, and packing decisions which must be coordinated in the process. Little mechanization is involved. Staff experience is obviously crucial, though the computerized information on routes, loads, United's office hours around the world, transfer points, other airlines' schedules, customer identification and needs, cargo type, special handling, etc., helps. The staff must keep track of perishable items in the cool (4°C or 40°F) room, live animals and pets, dry ice shipments (which cannot be in the same airplane compartment with animals because of the suffocating carbon dioxide it gives off), hazardous materials, and other special considerations.

Although the operation is very uneven, the area is very busy during the loading of an aircraft so this terminal seems to be working close to its practical capacity. Another plane perhaps could be handled if scheduling were convenient, and if more passenger aircraft belly volume were to be moved, but a large increase in freight volume could easily swamp the present system. More staff would probably not help much because of the increased coordination that it would entail. A larger aircraft would tax the staging area and slow the loading process. It might also require new containers which could make some of the handling equipment useless. The decision and documentation phases would undoubtedly suffer seriously. These are the kinds of problems which must be faced before a larger air cargo business can be handled. The larger air freight systems are essentially different, not only in scale but also in kind.

1.4.4. Military Air Cargo

Military Needs: Military air cargo needs are different from civilian needs in several important aspects. First is cost: the military must deliver to a wide variety and quality of airfields on short notice and must unload without specialized ground equipment. The cost of providing such versatile designs is high and generally not feasible in a profit-making operation.

Air freighters similar to the C-130, C-141, and C-5A were designed for freight use with a high wing and "kneeling" landing gear so that the cargo doors could be near ground level. Lower ramps and loaders are simpler and can be carried in the aircraft or built into it without large weight penalties. Nose or tail doors allow vehicles to drive in (or through), and long loads or other oversize cargo which could not fit in side doors can be accommodated. The rear door also allows military cargo drop by parachutes.

In contrast, the B-747F and B-747C have nose doors but not tail doors, and the doorsills are 4.9m (16ft) above the ground. The standard Air Force 436L system 40K Loader can reach a height of about 3.7m (12ft), sufficient for loading the biggest military aircraft, the C-5A; however, a 1.2m (4ft) adapter platform must be placed under the 40K loader in order to load B-747F/C. A second 25K Loader is used to shuttle cargo from the assembly area to the 40K Loader on the platform, which lifts the freight to the nose door level.

A second area of difference in military cargo needs is related to load density. The C-5A is designed to carry tracked vehicles and the battle tank (M-60). It thus has a much stronger floor than the 747F. Density of air cargo in commercial transportation averages well under that required to make use of the maximum lift available. Containers use (and waste) more space, so that the 747F with 2.44m x 4.90m (8ft x 16ft) crosssection plus lower deck for LD containers, and the proposed "lifted" version with two 2.4m x 4.9m (8ft x 16ft) decks, are more efficient for a system based on the standard intermodal container, than the C-5A which measures 4.0m (13ft) high and 4.9m (16ft) wide in one large cabin.

A military cargo system called the 453L is based on the 2.24m x 2.74m (88in x 108in) pallet loaded up to 2.44m (96in) high or 4750kg (10 500lb). This is different from the "Igloo" commercial container and from the ISO containers, so that there is little hope of an efficient interchange of cargo or cargo capability between the current military system and the proposed integrated cargo system.

Military Air Cargo Facilities: The need is greater to standardize material and units in a world-wide military operation than in civilian operation because of the single source of supply and critical planning requirements. It is also more feasible, since there is one overall authority. The Air Force cargo system, while it is based on a pallet size which is not compatible with the ISO intermodal container, is based on one standard, so the handling concepts are, in theory, transferable. In fact, however, the military cargo systems have different demands, routes, and schedules. They are not especially efficient in the terms important to commercial users because of the costs, peak needs, and lack of established routine operations.

A new U.S. Navy Air Freight Terminal Facility, which might offer ideas for terminal design, is being developed for the Naval Air Station (NAS) in Norfolk, Virginia. A concept study (ref. 34) determined that a gross area of 5700m² (61 000ft²) at a cost of about \$3 million would be appropriate. However, the best concept was relatively unsophisticated, at least compared to the Lufthansa operation in New York, which will be discussed in Section 1.4.5. It

will be more like the United Airlines cargo operation in Baltimore (BWI). The NAS terminal is to have six originating and seven terminating truck docks and 21 docking positions for K-loaders, each with a pallet conveyor. Up to 100 pallets can be on conveyors, and any pallet can be moved to another conveyor station by means of a motor transfer cart, manually controlled. Maximum design volume is 180 tonnes (200 tons) per day, one-third of which is terminating at NAS. There are spaces for customs and for refrigerated and hazardous materials. A staff of 50 can be accommodated.

While this new design for NAS may be advanced in terms of the systems used in the military and may meet their needs very well, it does not provide the kind of innovation necessary for a high-volume containerized cargo operation. The forklift truck, an integral part of the NAS concept, is limited in container handling because of size, weights, and damage potential. While the forklift will continue to be used in the loading of each container, the containers themselves need more efficient means for guiding their movements and for documenting the contents.

1.4.5. An Example of Containerized Freight Movement

In contrast to the great majority of current cargo handling techniques, there are a few operations which are now capable of handling cargo in the manner envisioned for the nodes of an integrated cargo system, in which a small number of standard container types are handled routinely. One major problem in the growth of this capability is the intermodal character of the containers. The intermodal-ocean container began with the Sea-Land operations in 1956. By 1968, despite widespread predictions to the contrary, over 100 vessel companies were involved. Containers became more popular, and by 1976 there were 1.6 million 6.1m (20ft) ISO container equivalents in service (ref. 35).

The sea-going containers are stacked six high in the hold and extend above the main deck of the containership. This requires a strong, and thus heavy, box which is costly to move by air. Even though the container could weigh almost as much as the cargo without overtaxing the lift capacity in today's low density air cargo, the added weight does increase fuel costs.

A lighter intermodal-air container has been in use since 1975. It can be stacked only two high, which limits its use in ships. Nevertheless, 380 of them are in use in 1978, and 800 are projected by 1980.

Aircraft now available to handle the ISO containers include 58 B-747's with main deck cargo capability delivered in mid 1978 and in service with 26 operators. Of these, about 36 are cargo-only aircraft. The B-747 is now serving the continental U.S. and 32 other airports around the world. Table 1.5 lists the carriers flying cargo versions of the B-747 at this time (see also Table 1.2).

In 1973, Lufthansa (ref. 28) became the first to carry ISO standard containers in B-747 aircraft in regular service. The Frankfurt to Kennedy (NYC) service required a considerable investment in handling equipment and facilities.

Table 1.5

CARRIERS FLYING B-747 AIRCRAFT IN U.S., 1978

Rev**	Code	Airline
8	AA*	American Airlines
14	AC	Air Canada
6	AF*	Air France
-	AI	Air India
15	AZ	Alitalia
11	BA	British Airways
-	BN	Braniff International Airways
-	CP	CP Air
3	FT*	Flying Tiger
-	IB	Iberia
7	JL*	Japan Air Lines
-	KE	Korean Airways
12	KL	KLM-Royal Dutch Airlines
4	LH*	Lufthansa German Airlines
-	LY*	El Al Israel Airlines
10	NW*	Northwest Orient Airline
-	OA	Olympic Airways
2	PA*	Pan American World Airways
-	QF	Quantas Airways
13	SB*	Seaboard World
-	SK	SAS - Scandinavian Airlines
-	SN	Sabena-Belgian Airlines
-	TP	TAP
9	TW	Trans World Airlines
5	UA	United Airlines

* All-cargo versions B-747 are used by this airline. Cargolux, Iraqi, and World lines also have them.

** World rank in revenue ton-miles for cargo, 1976. Aeroflot is number 1. (Ref. 46, 48).

The 9000m² (97 000ft²) terminal at NYC cost \$16.2 million. However, it requires only 45 minutes from the opening to the closing of the nose door to remove and replace about 90tonnes (100tons) of freight in a load of 28 containers, each 3.05m (10ft) long. These are handled on a regular six-day per week basis. A computer-controlled oversize storage machine handles ISO containers, igloos, and various pallets in its 227 storage openings which rise to 15m (50ft) above the floor. All transfers are powered, and transfer platforms can raise and tilt to mate with the aircraft doors and floors, though the telescoping dock never actually touches the relatively delicate aircraft nose structure.

Each freight unit is numbered. The transfer platform operator enters the numbers via an on-board CRT terminal for storage and the various transfer operations which the computer controls. Containers are emptied and sorting is done with the machine serving as a transfer cart to tow carts and work stations. Five conveyors at the work stations transfer material to or from the 26 truck docks via tow carts. On command, the carts move to customs or truck docks with the destination determined by mechanical probes which are read automatically. Full containers or those too large for tow carts are forklifted directly to the heavy storage areas.

Entering freight from trucks goes by roller-bed truck to container storage or to work stations for containerization and then to storage. Cart numbers and cargo identification are assigned by the dispatcher from the airbill. A photoscanner reads cart numbers for controlling their movements by computer.

The DEC single-process computer takes inputs from optical scanners and load sensors and from various operators in the terminal. As a cart leaves storage, the computer prints out the previous cart's destination, so the operator can manually set the mechanical probes for the next destination. The computer keeps track of the contents of the storage area, the airbill numbers of the contents, the total inventory, status reports on loading and load staging operations, and other routine information, as well as controlling the movements of the carts and the storage machine. Two CRT terminals, five teletype units, and a telephone net complete the system.

Lufthansa ranked fourth in world cargo revenue ton-miles in 1976 (See Table 1.4), and now (ref. 36) flies two B-747F and six B-747-200B combination aircraft. The utilization of specialized, computer-controlled systems is thus not yet very intensive, though Lufthansa also flies the same aircraft to Boston, Philadelphia, Chicago, Los Angeles, and Amsterdam. Growth, based on the experience of mechanized container operations such as Lufthansa's, is needed before a world-wide air cargo system can be said to exist. In 1977, there were 115 all-cargo (including 14 widebody B-747F) aircraft, 303 other widebody combination aircraft, and 1842 other combination aircraft being flown by U.S. scheduled airlines. The all-cargo aircraft served 49 airports and the widebody combination aircraft served 53. Of the 631 airports served in the U.S., with their 1007 airline operations facilities, 702 freight operations areas were maintained separately from passenger facilities. Only 3 were reported which had off-airport freight facilities. In 1976, only 6.7% of freight shipments were containerized by the shippers, though 17.7% of all freight volume was shipped in containers. As mentioned before, the load

factors were not especially good, with 50-60% usual and an occasional 70% seen (ref. 37).

1.4.6. Potential and Problems in Expansion of Air Cargo Business

While growth in air cargo demand has not been as rapid as most of the predictions of the past few years, the potential continues to exist as demonstrated by the fantastic growth of firms such as Federal Express, Burlington Northern Air Freight, and many other freight forwarders. Where new service is provided, the demand seems to be generated.

A basic problem in expansion of air cargo capability is the capital which must be risked on the promise of new business. Federal Express Corporation needed \$50 million before one cent of revenue was received. Lufthansa invested \$16.2 million in the New York facility alone in order to handle intermodal containers more efficiently, and similar investments will be needed in Frankfurt, Amsterdam, Bogota, Boston, Philadelphia, Chicago, Los Angeles, and other major terminals if the system is to be fully exploited.

This kind of investment and the innovation which results in rapid growth is not typical of the passenger-oriented major airlines. On the other hand, according to one airport cargo manager, Seaboard World Airlines has a facility in which a B-747F can have its belly compartments being loaded, its nose and side door in use unloading the main deck, and an engine being changed, simultaneously, in one large building. Innovation has its risks, of course, and Seaboard apparently had an automated tow-cart system with drag cables in the floor which did not prove practical and had to be abandoned. There have been other failures in automation, where reliability or cost were not controllable or the real needs of the system were not being met, either initially or as the conditions changed with time.

Cargo handling and loading is widely recognized as a bottleneck area which limits the productivity of air shipping. As in all production systems, the decision to remain manual or to automate depends largely on volume or throughput. Expansion is possible only to a degree, after which automated approaches are necessary for both capacity and efficiency. Given a current capacity of 100%, improvements, more staff, and greater stresses can result in larger throughputs, perhaps to 140% or 160%. Further increases can be gained only by a change in the system: larger, automated facilities provide, in one step, perhaps a 300-500% capacity increase. Some of this new capacity will go unused for a time resulting in higher unit cost, but none of the new capacity is available without a large investment, risk, and disruption of current methods.

Improvements in loading are illustrated by the various methods used in main deck loading of the DC-10F. An on-board loader is available which can load or unload the aircraft in 137 minutes (ref. 37). This can be speeded up to 93 minutes by use of a light-lift forktruck. If specialized mobile or transporter loaders are available, the time can be cut further to 64 minutes or 50% of the original. However, a loading dock which allows direct transfer from a dock into the aircraft main deck can reduce this time to 48 minutes or

34% of the original. This requires the cost of mechanization to a narrower range of equipment and of specific aircraft taxiing and parking requirements.

Loading and handling technique, of course, is primarily dependent on the container or mix of containers involved. Where aircraft which take the large intermodal air freight containers are in use (see Table 1.2), specialized equipment is necessary and feasible. Improvements are being made in transporters, A-frame cranes, elevator-conveyor-ramps, computer-controlled movements, etc., and the number of lift-transfer-slide operations is being reduced for any one container as standardization becomes routine. On-board ramps and lifts require weight and design sophistication that are justifiable only for military needs. Duplication of cargo handling equipment at a large number of freightports also requires a larger investment as the sophistication of the techniques increases and makes the greatest possible standardization and interchangeability of equipment desirable.

Alternatives can be devised for many of the methods now in use, though a distinction must be retained between the freight facilities handling large containers and those handling belly types or bulk. For example, in main deck loading of aircraft like the B-747F, it is possible to raise each container to the nose door 4.9m (16ft) above the ground or to build the container handling equipment to deliver units at that level. The high dock not only is a potential safety hazard, but the availability of an aircraft like the lower L-500 would make such a high dock unnecessary and even unuseable. An aircraft elevator, designed to support the landing gear, may be more practical than the mechanism for a variable height output from an automated system handling long, heavy containers full of fragile materials. The engineering of elevators is a more routine process than the design of handling equipment, and the flexibility for aircraft types is retained. The rear-loading aircraft would still present a problem with tail clearance, however.

1.5 INTERMODAL TRANSFER

1.5.1. Transmodal Movements and Multimodal Systems (Adapted from ref. 5)

Throughout this report, the assumption is implicit that well integrated transportation systems with good methods for intermodal transfer would make it possible to use each mode optimally. For each transportation mode there are sets of circumstances under which it is superior to the alternatives. When a mode is used under less favorable conditions, it is less satisfactory in some sense than an alternative. Where a movement of either people or goods has some portion of the journey outside the optimal "window" of the selected mode, then a transfer to the optimal mode is suggested. Whether such multimodal movement is executed depends on whether the cost of transfer is less than the additional cost of operating suboptimally for a portion of the journey. The word cost here refers to costs of all kinds including time value for the cargo involved.

This line of reasoning suggests that the performance at the node or connection between two or more transportation modes is an important determinant of the degree of network optimization that is possible. In general, the performance at the connection points is the weakest link today for reasons that are perhaps more institutional than technical.

There are two aspects to transfer terminal (nodal) performance. The first is the transfer facility itself, its efficiency, safety, and amenities. The second is how long a person or cargo has to wait for the next process or the next vehicle that is to move it. Terminal performance largely determines link performance. How long a person or shipment spends in the terminal also is a function of the frequency of service and the scheduling on the links. A large part of what appears to be an inordinate amount of time cargo spends in terminals may be less dependent on design or efficiency, than on the scheduling and size of the vehicles. Further, the average speed of the links is a function of how long the vehicle is stopped at the terminal to load and unload, which is a function of terminal efficiency.

Another determinant of the degree of network optimization possible is the magnitude of the difference in the cost and performance of one mode and that of the next best alternative. For example, if long haul air is already marginally superior to long haul truck, there is no incentive for large investments in fast, efficient terminal transfer terminals. Only the promise of substantially superior air performance would provide that incentive.

Our transportation system has evolved with each mode operating essentially independently. Each mode attempts to serve as large a market as it can. This places a premium on versatility, a preference for a wide window of "not too bad" performance rather than a narrower window of superior performance. This blind competition is a disincentive to developing a good intermodal transfer capability.

Thus, the penalty the nation pays for poor intermodal transfer goes beyond the currently perceived costs and inconvenience; it has also been an inhibitor of maximizing the potential of the individual modes.

This observation implies that there is a cyclic aspect in moving toward truly multimodal networks: Current modal design and operation tends to even up the levels of performance among alternatives and decreases the incentive for building good intermodal transfer facilities. In turn, the absence of such facilities inhibits the narrowing of modal service for more efficient operation and thereby decreases the efficiency of that mode.

This suboptimization of each mode rather than the optimization of a multimodal network is largely the result of the lack of overall organization. If multimodal transportation companies or consortia were permitted and encouraged, the perceived incentives would shift toward network optimization. There are also potential disbenefits to permitting such organization. The various existing interests deserve careful attention, but the potential efficiencies and national benefits of an optimal network also deserve consideration.

1.5.2. Progress in Intermodality

The advanced cargo system is designed to provide mass air movements on routine schedules based on the needs of large-volume shippers. Small-volume shippers will have their packages consolidated into containerized lots, after which the shipments will follow the same procedures as larger shipments.

The NASA-Lockheed "Cargo/Logistics Airlift Systems Study (CLASS)" (ref. 49) describes the future air cargo transportation scenario as a coordinated surface-to-air-to-surface operation. The motor carrier industry will perform connecting services between units of the air mode as well as direct service and connecting services with rail and water transport. The air phase will have full intermodal compatibility with the surface transportation modes. A family of all-mode cargo load devices will have been developed for both air and surface use. The load devices will not be captive of any single mode but will be covered by equipment interchange agreements on all domestic and international routes. The system will handle shipment to be packed in truck-load or container-load lots by shippers, forwarders, and surface carriers.

Unitized loads will be trucked to and from airport centers for distances up to several hundred miles. In the "Summary Report on Intermodal Cargo Tests" (Project INTACT) by Lockheed-Georgia (ref. 38), it is shown that large all-cargo aircraft can be designed and operated so that direct operating costs will be low enough to provide attractive freight economics relative to surface transportation. The analyses also conclude that the present system of air movement of small shipments will not develop to a point where the productivity of a fleet of large cargo planes would be utilized effectively. Four observations that support this conclusion are;

- (1) Small packages and emergency shipments will not provide sufficient volume to justify a fleet of large cargo aircraft.

- (2) Large cargo aircraft require large unit cargo loads for high overall efficiency.
- (3) The cost of handling individual shipments can be reduced through an optimized cargo unitization system with compatibility between the internal dimensions of the aircraft and the external dimensions of the unitized cargo.
- (4) Large unit loads must be truly intermodal for direct interchange with surface transportation. The motor carrier is the way to optimize most of the interchange between the modes.

In terms of customer service, the present mode of air service, which is primarily small package emergency service, is now approaching maturity. This air cargo service does meet the needs of small shippers and will continue to do so. However, it does not nearly meet the needs of large shippers with routine volume shipments. Achievement of a viable large-volume air cargo service will depend on the following:

- (1) Use of large containers that can be filled by shippers, surface carriers, or forwarders at off-airport sites.
- (2) Complete compatibility with the surface freight systems to allow efficient ground interface and connecting service for onward freight movements.
- (3) Cargo airplanes designed specifically for freight service and uncompromised by passenger considerations.

1.5.3. The Intermodal Aircraft

For good intermodal transfer, the ideal air freighter would have these characteristics:

- (1) Cargo compartments and doors located and of such dimensions that speed in loading and unloading are facilitated.
- (2) Height of sill (distance between ground and bottom of cargo door) compatible with other modes of transportation or standardized for loading equipment compatibility.
- (3) Dimensions of cargo compartments and doors large enough to accommodate all standard containers.

In general, the ideal air freighter would have cargo doors to allow nose or tail loading (preferably both), compartments large enough to receive and secure a 2.44m x 2.44m x 12.19m (8ft x 8ft x 40ft) container, height to sill of 1 to 1.5m (3 to 5ft), and a ramp available for loading.

Comparing flight characteristics, load limits, and dimensions of present and future cargo aircraft with the required characteristics of the ideal air

freighter, it can be seen that an aircraft similar to the Lockheed L-500 (civilian version of the C-5A "Galaxy"), one similar to the Boeing 747-200F, and an air freighter similar to the Lockheed L-100-50 "Hercules" stretch version are the acceptable aircraft for dedicated air cargo. The L-500 type and the B-747 type have similar payload and range characteristics. Choosing on the basis of intermodal suitability, it would appear that an aircraft similar to the L-500 is preferable because of the ease of loading. It is assumed that the defects in the current C-5A landing gear and wing will be corrected and the aircraft will be completely airworthy. The aircraft fleet for dedicated air cargo would consist of the L-500 type for long range and heavy loads, the L-100-50 for medium ranges and loads, and motor trucks and trailers for short range containerized cargo. Although this system concept does not include provisions for small individual packages, the regularly scheduled passenger carriers have ample capacity for belly cargo and will continue to transport small packages for some time to come.

1.5.4. Transfers Between Aircraft and Other Carriers

Standardized intermodal containers will facilitate the transfer of cargo between carriers. Standard containers in this study have been assumed and are described in Chapter 2 (ref. 39). They are the "M-1" containers measuring 2.44m x 2.44m x 3.05m (8ft x 8ft x 10ft) and the "M-2" container measuring 2.44m x 2.44m x 6.10m (8ft x 8ft x 20ft).

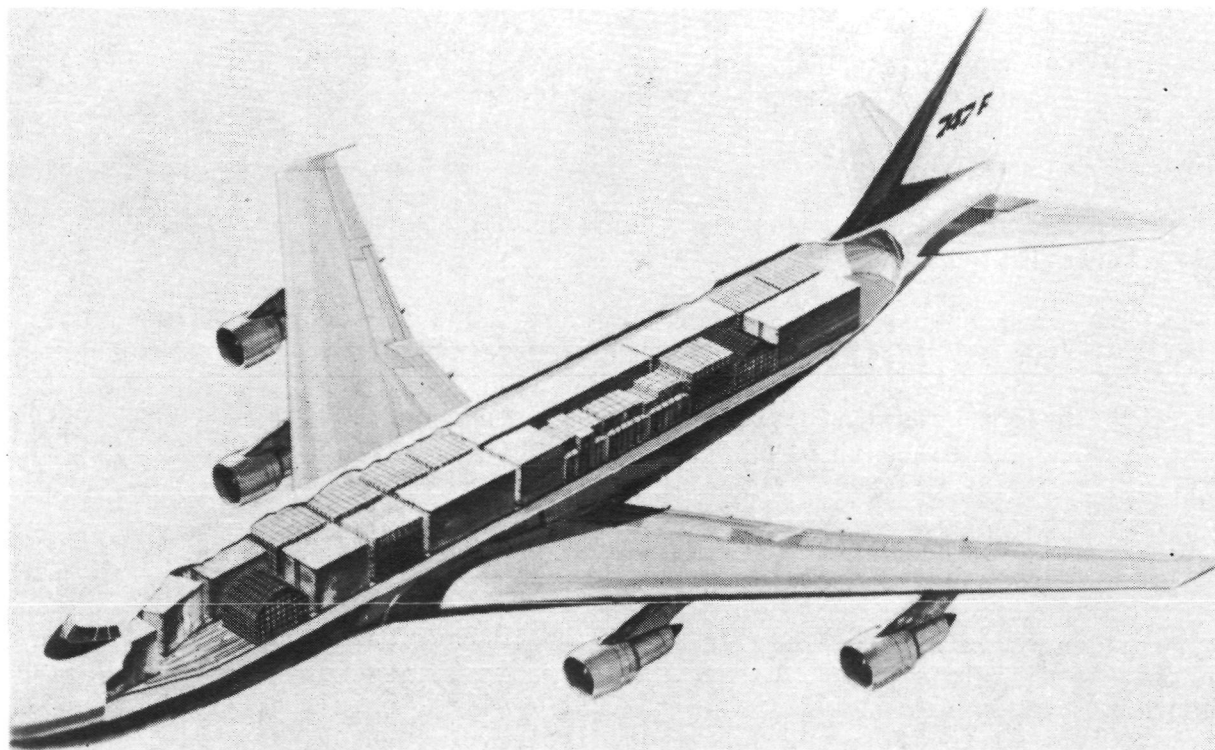


Figure 1.31 POSSIBLE AIR CARGO TYPES AND ARRANGEMENTS (Source: Courtesy Boeing Commercial Aircraft Co.).

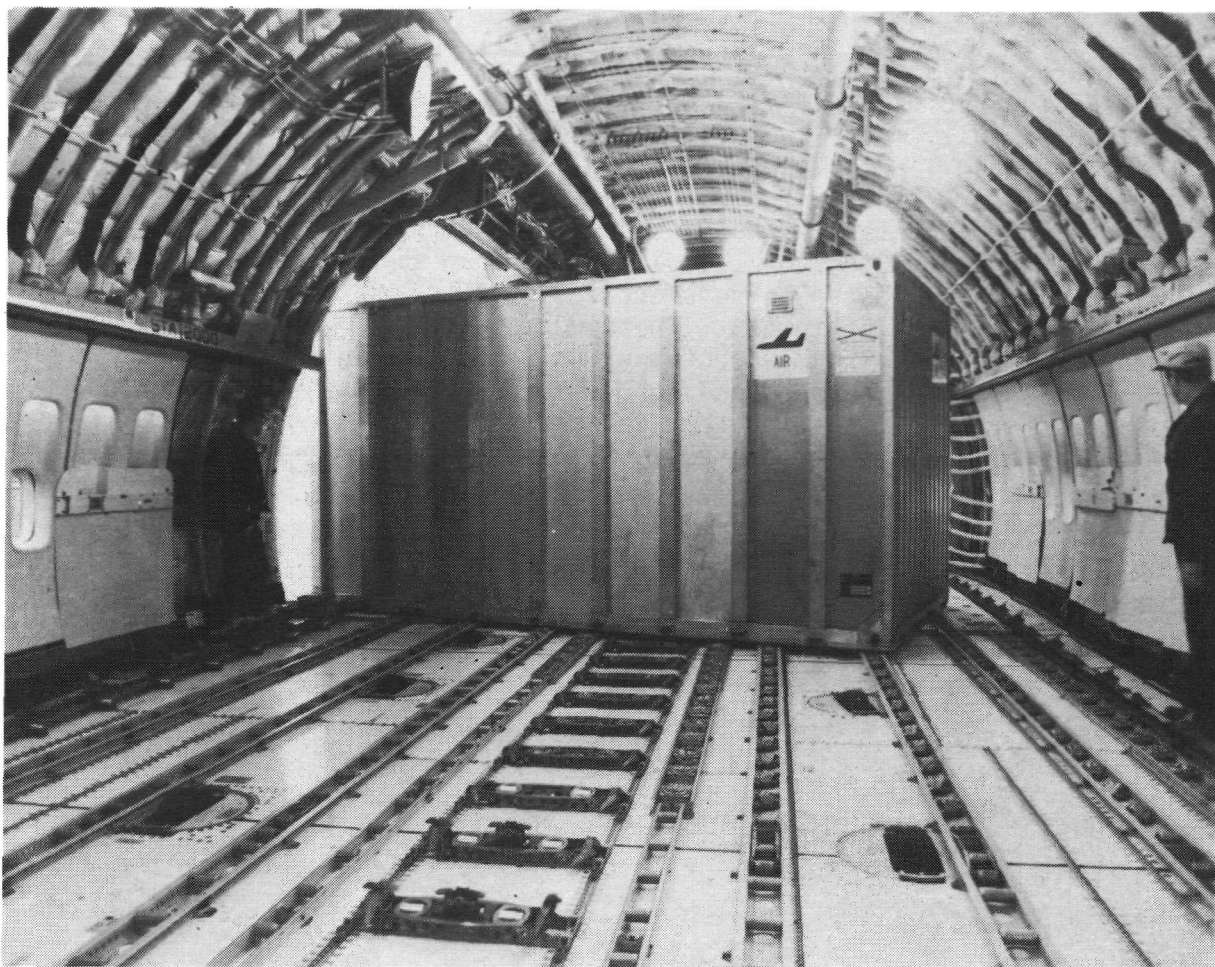


Figure 1.32 SIDE LOADING AN AIR FREIGHTER (Source: Courtesy Boeing Commercial Aircraft Co.).

Although this is the adopted standard, provisions ought to be made to utilize the 2.44m x 2.44m x 12.19m (8ft x 8ft x 40ft) container as well in order to optimize truck-trailer use and to expedite the transfer of trailer-load lots. The longest container, which is the actual trailer body, is the heart of ground transportation on roadway, rail; and water. Complete intermodal transfer of trailer-size loads already exists between truck-trailer, rail, and water carriers. Many other sizes and shapes of containers and pallets are available as well.

Figure 1.31 (courtesy of Boeing Commercial Airplane Company) shows a cutaway view of an air freighter fully loaded. Various sizes and shapes of containers, pallets, and other cargo are shown stowed in the aircraft. Included are three of the standard-size containers mentioned above. Not shown are "roll-on roll-off" type cargo such as trailers and motorized vehicles and equipment. Though not necessarily of standard size, this type of equipment is truly intermodal and must be considered in air cargo system design. This is especially true since the system design includes provision for transporting military cargo including motorized equipment

military cargo including motorized equipment. Ramp loading is essential in these cases for rapid and efficient loading and unloading. In the case of an entire load of fully motorized equipment, nose and ramp openings would allow simultaneous rapid loading and unloading.

Figure 1.32 (courtesy of Boeing Commercial Airplane Company) shows an M-2 container being loaded through the side door of an air freighter. On-board mechanized floor rollers shown here are designed to expedite loading with minimum use of outside equipment. The figure further illustrates the limitation of side door loading. The M-2 container shown is the largest that can be loaded in this fashion, and even it could be loaded much faster through a nose or tail opening. The figure further indicates that the opening shown is the smallest allowable since it can barely accommodate the standard container.

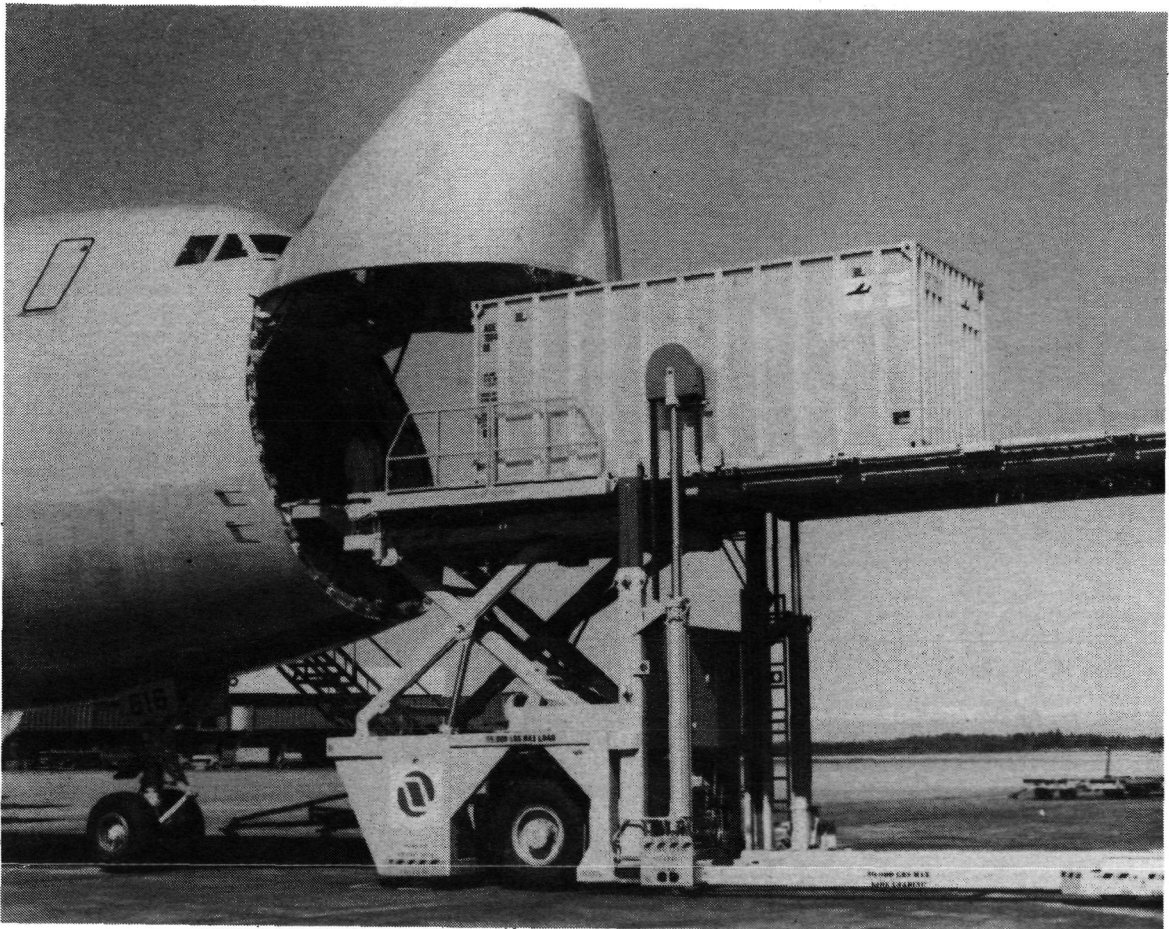


Figure 1.33 NOSE LOADING AN AIR FREIGHTER (Source: Courtesy Boeing Commercial Aircraft Co.).

Figure 1.33 (courtesy of Boeing Commercial Airplane Company) showing a nose-loading operation illustrates three salient features, two positive and one negative.

- (1) An M-2 container is being nose loaded, indicating the relative ease and rapidity of this "straight-in" loading method. The 12.19m (40ft) trailer-size containers could be loaded just as easily in this manner. The Boeing Company's Air Freight Systems Office reports that the B-747's main deck can be fully loaded with containerized freight through the nose door in 25 minutes and through the side door in 30 minutes.
- (2) The figure illustrates one type of loading equipment widely used and recommended for the typical situation in which ramps or platforms are either not available or at a height too low for the aircraft opening. This motorized transport loader can pick up the container at one location, transport it to the air freighter, elevate the load to sill height and, with its mechanized rollers, move the container into the aircraft opening. Many loaders of this type are available, such as the Kornylak Corporation high-lift "Karry All" scissors-lift truck. The same kind of equipment can just as readily load and unload trucks and trailers and, in fact, is ideal for loading intermodal containers between truck or trailer and aircraft.
- (3) The figure illustrates the disadvantage of an air freighter whose opening is much higher than other modes of transportation. An aircraft with the recommended sill height of 1 to 1.5m (3 to 5ft) would allow for much faster loading and without the need of the expensive loading device shown.

Figure 1.34 shows container-loading operations at dockside, illustrating intermodal terminal transfer methods between rail, truck-trailer, and ship. These ideal facilities include provisions for loading rail cars, ships, and truck or trailer beds. In the foreground, a container is being loaded by a dockside crane with telescopic spreader. This spreader, similar to the one manufactured by A.S. Bromma Smides and Mek Verkstad of Stockholm, is electrically and hydraulically operated and can handle all sizes and types of containers.

In the left foreground of Figure 1.34 is shown the versatile straddle-container carrier that can load M-type containers up to 12.19m (40ft) in length from and to rail cars or trailer beds, can transport them to other locations, and can stack them three high. The type of straddle-container carriers suitable for the air cargo system are the Clark Company model 830L van carrier, the Valmet Oy of Helsinki "Valmet stacking straddle carrier," and the Mitsubishi, Tokyo, V-SC 4023 straddle carrier.

In the background of Figure 1.34 is shown the dockside rail-mounted container crane very useful for moving containers to and from ships and onto or off of cars, trailer beds, and warehouse platforms. Cranes suitable for use in intermodal transfer are those similar to the "Universe" multipurpose dockside container crane manufactured by Ishikawajima-Harema of Tokyo.



Figure 1.34 INTERMODAL TRANSFER EQUIPMENT FOR RAIL, TRUCK AND SHIP (Source: Courtesy Boeing Commercial Aircraft Co.).

All of this container-loading equipment is illustrated and described in Jane's Freight Containers (ref. 39).

The Project INTACT study (ref. 38) stressed two major underlying assumptions to characterize intermodal transfer:

- (1) All freight entering or leaving the air cargo terminal will be by means of motor carrier.
- (2) Cargo will be loaded into highway vans or intermodal containers at off-airport sites. These load devices will be driven to the airport and loaded aboard aircraft with a minimum of handling.

Optimum efficiency in intermodal transfer is obtained by loading containers, or even the trailer itself, aboard a C-5A type aircraft ramp or by using docks compatible with trailer-trucks and with the height of the sill of air freighters, facilitating rapid loading and unloading. Guide rails for wheeled vehicles and containers, container lift gantries, and self-contained, wheeled container-loading shuttles are devices illustrated in Project INTACT.

1.5.5. Off-Airport Consolidation

Intermodal transfer is based on the premise that all cargo to be transported by air freight is containerized. For some time to come, however, there will be shippers of less-than-container-size loads or shippers with container-sized loads of small packages who do not wish to bother with or do not have facilities for containerization. With more than half of air cargo tonnage consisting of small packages, some means for containering, sorting, and documenting them must be part of the intermodal transfer function.

The ideal cargo terminal or freightport should be divided into two or more areas (ref. 40) since the cost and scarcity of airport real estate directs the use of off-airport facilities for the receiving, storing, sorting, consolidating, and breaking down of freight units. Pallet and container loads would be trucked to the airport for flight consolidation, staging, and loading into freighters. Off-loaded containers simultaneously would be stripped from the aircraft and immediately dispatched to some remote handling and breakdown facility or truck distribution center. The off-airport parts of the terminal would consist of truck docks, a high-speed sorter capable of handling 6000 packages per hour, one igloo and container storage complex, one office complex, several automatic encoding stations and collating lanes, mechanized pallet build up devices, pallet and container stations, and outbound trailer loading docks. This portion of the terminal is essentially a transfer operation. Individual shipments are logged in and identified. It is desirable to have an "interrogable tag" by which the package could be machine sorted by type or by destination.

All storage is accomplished outside the building in semi-trailers. It is assumed that pallet breakdown and segregation is accomplished at a local delivery warehouse. Another invention necessary for this concept is a device to consolidate and breakdown random packages to and from container or pallet modules. A number of palletizers already on the market efficiently build uniform cartons into pallet loads. By combining the interrogable tag, a package size measuring machine, mechanical handling devices, and a computer, much more efficient cargo consolidation operations would be possible.

Michael L. Mastracci writing in the October 1968 edition of "Interavia" (ref. 40) described and illustrated an elementary air cargo distributions center. The center, designed, engineered, and installed by the American Machine and Foundry Company, turns around belly freight in 30 minutes. It utilizes the latest sorting and electronic devices to process 34 000kg (75 000lb) of mixed cargo per hour. It accommodates loose and palletized cargo and includes an electronic accounting system that weight-manifests cargo by flight and destination.

In general, intermodal transfer concerns not only the handling problem, but economics, the operational environment, personnel and time limitations, and all constraints. With the help of a few new developments, this ideal can be approached and a much more efficient cargo system realized.

1.6 AIRCRAFT MIX

1.6.1. Existing Aircraft and Derivatives

An air cargo system of greater capacity and efficiency obviously depends on the characteristics of the components which make it up. While designers can incorporate almost any features desirable in an aircraft, the time and capital investment involved in new design is such that any new aircraft must be assured of replacing a major portion of current ones in use to be economically justifiable. For the next few years, we must use designs that are already in production. In three to five years, derivatives of current models (wider, longer, taller, new doors, larger engines, etc.) could be available in quantity. New designs (ref. 41), once justified by demand, require several years for development, while features desired in a cargo aircraft but not compatible with the needs of passenger model raise the investment risk.

The following sections will present the candidates for cargo use among aircraft in use today and describe the features that are desirable or available for the various needs of an integrated cargo system of the immediate future.

1.6.2 Quick Change and Combi Concepts

In recent years, there has been an upsurge of interest in the air freight industry which is being served by (a) dedicated cargo aircraft, (b) the belly holds of passenger aircraft, (c) "combi" in which a wall is installed in the main deck so that a section of it is for cargo while the remainder is for passengers, and (d) QC (quick change) aircraft which can be converted quickly from an all-passenger to an all-cargo configuration and vice versa.

The aircraft offers the prospect of increasing utilization by extending the period of daily use. It can be employed as a freighter during the night when there is relatively little requirement for passenger operations and converted quickly to passenger use each morning. It also permits freight services to be offered in situations where demand is insufficient to utilize a freighter fully. However, some of the potential of QC aircraft has diminished in recent years as more airport authorities have imposed restrictions on night operations, particularly by jet aircraft. This poses problems for the air freight industry in general, but is particularly serious to the QC carrier. In addition, the greater risk of damage to the interior of the QC aircraft, coupled with the frequent complaints of residual odors, reduces its appeal for passenger use.

The combi appeals to some air carriers because of its ability to consolidate freight and passengers, now being carried by two smaller aircraft, into a single aircraft. An obvious example is the B-747 combi which is capable of accommodating pallets as well as standardized containers up to 6.10m (20ft) in length in the tail section while providing passenger services in the forward

section. Again, it is not as good as it seems. Freight and passengers have different flight schedules, passengers primarily during the daytime and freight primarily at night. In addition, passenger traffic often leads to the provision of separate terminal facilities located at different parts of the airport. Upon arrival at the passenger apron, freight vehicles would be hampered by, and add to, the congestion around the aircraft.

1.6.3. Desirable Aircraft Features

Until the introduction of wide-body jets into commercial use, there was little capability for moving the intermodal containers by air. The shape of the belly holds of aircraft and the door sizes did not permit large unitized loads, making freight handling slower and more expensive. Freight had to be handled as individual consignments placed in position manually and then secured with nets. This inefficient process of handling freight presents difficulty especially when turnaround times are short. The main deck cargo containers like the Igloos (Type A containers) used in the DC-8 and other aircraft provide an intermediate step, but the trend towards large consignments means some freight cannot be accommodated on narrow-body aircraft, and greater efficiency is needed.

Unlike narrow-body aircraft, the wide-body jets are capable of accommodating unitized loads in the lower holds and on the main deck if used as freighters. Due to the shape of the lower holds, the type of containers that utilize hold space most effectively are neither interchangeable with those of other aircraft nor compatible with other modes of transportation (a detailed discussion of containers will be given in Section 2.1.1.). The introduction of the intermodal container concept represents a positive step towards eventual standardization of all containers in the cargo industry.

With the increasing need for intermodal transfer of large containers, ground handling of large volumes of freight traffic will have to use the nose or tail for access to the aircraft. Nose and tail loading provides the fastest rate of handling since freight can be loaded and unloaded simultaneously. The C-5A is an example of this type of loading, and as a military freighter, it is equipped with a tail ramp to allow loading without ground equipment. Civilian freighters normally do not have a tail ramp as such flexibility can be achieved only at the expense of substantial reduction in payload. Nose or tail loading eliminates the need to rotate freight as it enters the aircraft as is usually required with side door loading. On aircraft with large payloads, the increase in handling time due to rotation will increase the turnaround time. Nose loading can be used only when the flight deck is positioned above the main hold, as in the B-747-200F, since pre-flight checkout must take place during loading for short ground times. The L-100-30 Hercules was designed with tail loading through a door just 104cm (41in) off the ground to allow unloading directly to a truckbed or the ground with little or no equipment.

Access to an aircraft often poses a problem in relation to its sill height above the ground. Most aircraft require lifting equipment to raise freight to the aircraft sill. For example, the sill height of B-747-200F is 4.9m (193in), L-100-30 Hercules is 1.0m (41in), and B-707 is 3.2m (125in).

The variation in sill height simply means that adjustable lifting equipment covering at least this range must be provided for different aircraft types at the airport terminals. The need for such ground equipment will result in additional handling costs. In the case of C-5A, the nose and tail can "kneel down" to facilitate loading directly from truckbed level. But such flexibility can't be accomplished in large aircraft without being a burden to the total aircraft cost. Thus, it is economically feasible for only the feeder aircraft to be designed with a cargo floor at the same level as the truckbed. This will obviate the need for lifting equipment at a large number of smaller airports.

The above discussion points out the advantages of (a) standardization of containers, (b) nose or tail loading, (c) compatibility with existing ground equipment, and possibly (d) aircraft sill at truck height, if it is aerodynamically and economically feasible. The future dedicated cargo aircraft should incorporate in its design all of these desirable features, in addition to defined performance characteristics.

1.6.4. Medium- and Long-Range Transport

Accurately predicting the future course of the air freight industry is at best precarious, as has been demonstrated by poor predictions in the past. In view of the uncertainty in the future and the subsequent "go slow" attitude among air freight carriers, it is not unreasonable to assume that the wide-body jets will remain in service during the next decade. The large-capacity, long-range aircraft, such as B-747-200F, will be handling the freight traffic between the hubs, and the medium-capacity aircraft, such as some of those listed in Table 1.6 (ref. 42) will serve the traffic between major and minor hubs or major city pairs. The B-747 design especially appears to have flexibility for derivative growth. The B-747-200F and its stretched version will most likely continue to provide services in the 1990's, though there will be requirements for smaller freighters. As in the past, these short/medium-range freighters probably will be derived from then existing passenger aircraft.

As the advantages of containerization become more widely accepted by the shipping community, a larger share of the freight will be unitized in larger containers. Consequently, the narrow-body jets would gradually be phased out of the prime markets and replaced by more efficient freighters capable of carrying loads in the large containers. A new generation of smaller cargo aircraft may also result as the demand justifies them.

The consensus seems to be that by 1990 there will be a dedicated freighter equipped with quieter, more efficient engines capable of carrying at least 100 tonnes (200 000lb) payload over 6500km (4000mi) range. It will be nose or tail loading with a main deck which will accommodate intermodal containers up to 12.2m (40ft) long. The lower holds will accommodate contoured containers. For the medium range, there will be a freighter with quieter, more efficient engines which will carry a payload of 36 000kg (80 000lb) over a range of 2400km (1500mi). Loading will be through a tail or nose door, approximately 3m (10ft) wide by 2.7m (9ft) high to accommodate standardized intermodal containers. Payload and range are chosen in accordance with the hub-spoke concepts discussed earlier.

Table 1.6

	Aircraft Type	Payload 1 tonnes (1b)	Range km (mi)	Cargo Handling	Noise Level (EPNdB)		
					Takeoff	Approach	Sideline
	B-747-200F	113 (250,000)	5300 (3300)	Nose loading Accepts M type containers to 12 m length Side cargo door optional	107	106	98
06	L-100-30 *	23.1 max. (51,000)	3400 (2100)	Tail loading Accepts M type containers to 12 m length	98.4	99.1	93.9
	Hercules						
	A-300-B4FC (European Airbus)	37.2 max. (82,000)	4200 (2600)	Side loading Accepts M-1 containers	92	101	95
	L-1011-500	44.5 max. (98,000)	9800 max. (6100)	Side loading Accepts LD-3 containers	97	103	95
	DC-10-30CF	70.6 max. (155,700)	4800 (3000)	Side loading Accepts M-1 containers	104.4	109.0 (50 ⁰ approach)	99.7

* There is a proposed 'stretched' version, with 35' longer fuselage, designated as L-100-50.

1.6.5. Limited Role of Crane Helicopter (ref. 43)

A special NASA/Army/Navy committee examining a renewed interest in the heavy-lift helicopter has said that a heavy-lift civil helicopter derived from a military version could fill "civil needs in construction, logging, energy resources development, and cargo container distribution" (ref. 44). This statement is in line with the view that a crane helicopter could be used, on a selective basis, specifically for moving containerized cargo to and from congested cities within a radius of, say, 160km (100mi) from the terminal area. The helicopter has the inherent advantage of being immune to surface delays and it can fly over lakes, canals, and industrial areas rather than having to go around them. It thus can be operated with a high degree of schedule reliability. In addition, it is capable of serving any area without the necessity of large and expensive landing facilities and it operates below most regular air lanes. It can accommodate any truck-load size container so long as the loads are within its weight limitation. The configuration of the helicopter makes it ideal for rapid loading and unloading and will provide a unique interfacing unit if it proves economically feasible.

Air shipment is a comparatively expensive but superior form of transportation of goods. Its future growth will depend on the shipper's willingness to pay for the high transportation cost in return for short transit time. The latter allows a reduction in inventory and warehouse costs, lowers the danger of damage to goods in transit, and provides the opportunity for faster response to changing market environments. The future growth will be stimulated when the air freight industry is able to provide guaranteed overnight or even second day service between any two domestic cities. The crane helicopter has the speed capability necessary to make an overnight system operational in certain physically isolated or congested areas.

The crane helicopter being considered may be similar to the Sikorsky S-64F Skycrane (ref. 42), capable of picking up one or more standardized intermodal containers by means of the dual rails on the underside of the body. The containers, loaded at the terminal, could be moved by forklift or conveyor to the loading dock and loaded directly under the helicopter. Large shippers, and possibly air-freight forwarders, may load the containers themselves, in which case the containers can be picked up from their loading platform with a minimum of ground handling.

Upon arrival at the destination city or freightport, the containers can be released directly onto a flatbed truck for direct trucking to the consignees within the local delivery zone. In the case of a large shipper, the container will be deposited directly on the firm's loading platform.

"Reorganized and revitalized U.S. rotary-wing research effort is entering an intensive phase marked by the advent of advanced flight and ground-based facilities that will help provide this nation's helicopter operators with much-needed new technology." (ref. 45) Against a background of imminent advances in rotary-wing technology, coupled with the further deterioration and congestion of highways in the vicinity of possibly saturated airports in the 1990's, it is reasonable to assume that the future crane helicopter will be

more competitive with the truck and will play a more viable role in the air freight industry. Despite the well-publicized problems associated with high operating costs and noise level, it is believed that the limited role of crane helicopter in the short haul transportation should be explored. This will present a great challenge to current helicopter researchers and manufacturers to come up with a truly fuel-efficient and low-noise crane helicopter in the future. The other aircraft required to make the integrated air cargo system function already exist, though modifications are desirable and new designs will follow inevitably as demand dictates.

1.7 IMPACTS

1.7.1. Introduction

The purpose of this section is to establish the extent of the benefits or disbenefits which are likely to accrue from the actual implementation of a dedicated air freight system. In particular, the emphasis is upon the deleterious or undesirable affects which are likely to result, since an understanding of these impacts will improve management of the development and implementation of the advanced air cargo system. It is noted that a previous report (ref. 3) has already been produced on this subject.

This discussion is concerned only with those impacts which the air cargo system has upon the larger societal-ecological system in which it is embedded. The focus here is largely upon the network routes, schedules, aircraft choices, and fleet size. In later sections, the impacts of other components of the air cargo system will be treated.

1.7.2. Physical Impacts

Network design weighs rather substantially upon the fuel consumption requirements of the total air cargo system. A low connectivity hub-spoke network means the cargo must be transported over more kilometers, but larger aircraft requiring less fuel per tonne-kilometer of transportation will be used.

In addition, the Gellman report (ref. 3) suggests that large cargo aircraft might be used to transport minerals and ores. If this happens, it would result in lower in-transit inventories of these goods; in quicker response times to changes in market demand, and in shifts in domestic employment. There has been no indication that large cargo aircraft would be used to transport raw fuel resources such as coal, oil, or gas. As a partial solution to the backhaul problem, refs. 31 and 49 suggest only that refined minerals will become eligible backhaul cargo for select regions.

Network routes will roughly parallel those in existence today. These corridors will sustain higher traffic densities in the next 25 years without measurable impact.

Dedicated air cargo flights can be scheduled around existing passenger arrival and departure peak densities, thereby necessitating few additional airport runways. It is anticipated that such scheduling will not degrade service to the shipper or to the passenger.

Choice of dedicated freight aircraft to be deployed will have important impacts upon the associated airframe and engine manufacturers as will the fleet sizes and mix. At this time, it is difficult to determine whether

existing airframe manufacturing facilities will be able to handle the required production rate of the dedicated freight aircraft without expansion.

1.7.3. Environmental Impacts

The environmental impacts of new air freightport construction and existing airport expansion are discussed elsewhere (see Section 2.7.2.). Treated here are the impacts of the links of the network rather than the impacts of the nodes, for the reasons cited previously. The links or routes of the network determine where the aircraft will be flying. For the population located beneath these links there will be some slight environmental degradation in the form of vapor trails and noise. Fortunately, major international hub-to-hub routes are over water.

The development and use of new aircraft engines which are more energy efficient and quieter should allow routes over heavy population centers provided the aircraft is 2000m (6500ft) or more above the ground. These engines may permit night-time arrivals and departures into some airports.

The effects of the air cargo system upon air and water pollution are considered tolerable and in most cases preferable to the resultant air and water pollution accruing from transportation of the same cargo by surface modes. Solid-waste pollution by the air cargo system is considered negligible (see Section 2.7.2.2.).

The impacts of the air cargo system upon land use are considered elsewhere (see Section 2.7.2.2. and 2.7.2.4.).

1.7.4. Societal or Cultural Impacts

As the air cargo system grows and becomes more profitable, it is anticipated that organized labor will become more adamant and insistent upon its own terms. This poses the possibility for international labor organizations with extraordinary power -- enough to prevent an entire country from getting the food supplies it needs. Since this fleet of dedicated cargo aircraft could be used to airlift emergency medical supplies to disaster areas, to airlift much-needed weapons, foods, fiber, or precious minerals, an international labor organization which could stifle such operations might become a considerable political entity.

Second, the immensity of this system also gives rise to the possibility of increased international crime. The hijacking of a single freighter could have international implications. There may also be increased opportunities for smuggling (of drugs, for example).

Mechanization, inherent in containerization, raises the skill levels of the required employees at the same time it reduces their numbers. The current practice among leading air cargo firms seems to be to hire the best qualified people available for "unskilled" jobs such as local truck drivers in order to maintain versatility and judgement on all levels. As competition increases, the pressures to economize by hiring less competent employees could jeopardize

the system through inefficiencies and increased mishandling.

Finally, it would be possible for a country to launch a surprise attack on another country by airlifting a large number of weapons and soldiers into the country under the guise of air cargo carriers (the old Trojan horse trick).

Thus it must be reckoned that although this technology carries with it considerable opportunity to benefit society, it also increases the possibility for massive abuse.

The impacts of an air cargo system upon such other societal factors as international politics, foreign policy, domestic growth, employment, international trade, imports, exports, jobs, quality of life, distribution of wealth, health, new business, population migration, lower freight rates, and marketed goods are considered later in this report.

1.8 SUMMARY AND CONCLUSIONS

Following is a list of conclusions emanating from the network studies described in this chapter.

1.8.1. Conclusions Related to Connectivity, Routing, and Hub Location

1. A hub-spoke infrastructure should be used for movement of the cargo. This concept applies both to surface transport links and to air transport links. Thus trucks move the cargo to its first consolidation point -- the hub or feeder freightport -- and deliver it to its final destination. A hub-spoke arrangement lowers the connectivity of the network and increases the frequency of service for a fixed capital investment in aircraft.

2. Superimposed upon the pure hub-spoke network are numerous direct routes between city pairs over which heavy volume is transported -- enough to permit 50% of the total volume to be transported by direct routes.

3. Three large, efficient freightports should be developed in the vicinity of San Francisco, Houston, and New York. These dedicated freightports will serve as international hubs or "gateways" for movement of both domestic and international freight.

4. Central place theory may usefully serve in locating hubs and spokes for the network. The hierarchy of hexagonal areas provides for service to all areas, from the smallest and least efficient units to large continents utilizing efficiency of scale. No pure network organization will do justice to all special cases that have developed historically; there simply is not enough flexibility in any single system or concept.

5. An organized gathering of information on existing civilian and selected military airports should be undertaken so that rational decisions can be made on expansion potential in accommodating the larger freightports and consolidation facilities needed for hub and feeder portions of the system and for locating new intermodal nodes in which air cargo may or may not be the initiating force.

6. The economics of an advanced air cargo system should be studied from the point of view of its infrastructure; that is, compatible network, scheduling, and fleet sizing designs should be developed, and from these designs, the economics of the system can be outlined more comprehensively. This is the approach that is employed by the air passenger carriers.

7. Statistics and ranking of airports for cargo should be based on the larger of the enplaned or deplaned cargo moved. This is a more equitable base across airports since, unlike passenger traffic, cargo flows are often strongly unbalanced. This base would retain the peak handling nature of the airport's

cargo operation, though total volume would still determine the ranking for revenue purposes.

1.8.2. Conclusions Related to Aircraft

1. The use of extraordinarily large aircraft may, in spite of their economies of scale, have important routing and scheduling disadvantages. In particular, they:

- A. lessen the frequency of flights, thereby
 - 1. lessening demand which is sensitive to frequency of service,
 - 2. lessening the number of connecting flights,
 - 3. increasing the delays at the nodes of the network, and
 - 4. increasing the terminal storage required at each node.
- B. lessen the number of direct flights, thereby increasing the amount of consolidation and breakbulk handling required,
- C. increase the number of kilometers (miles) over which the freight must be carried,
- D. increase the length of time required to deliver the freight.

2. Aircraft which are too small also have decided disadvantages for routing and scheduling. In particular, they dictate highly connected networks over which many more aircraft are required in order to achieve reasonable frequency of service because of the larger number of routes.

3. Large cargo aircraft (such as the 747-200F, the 747-11/11F, L-500) appear especially appealing because developmental costs have already been largely amortized by previous sales of the aircraft, thereby lowering the price which the airframe manufacturer must charge.

4. The combined and quick-change aircraft concepts have particular appeal from a scheduling point of view. Their increased flexibility should permit greater utilization of the aircraft and should facilitate solution of backhaul and related scheduling problems.

5. Research activity should be directed toward the development of quiet, fuel efficient engines which could be retrofitted into existing large cargo aircraft.

6. The future dedicated air freighter should, if aerodynamically and economically feasible, incorporate in its design such features as (a) nose or tail loading, (b) compatibility with existing ground handling equipment, (c) compatibility with other modes of transportation, and possibly (d) aircraft sill at truckbed height.

7. Despite the well-publicized problems associated with high operating costs and noise level, it is believed that the limited role of the crane helicopter in the short haul transportation should be explored. This presents

a great challenge to current helicopter researchers and manufacturers to come up with a truly economical, fuel efficient, and low-noise crane helicopter in the future.

8. A more formal study of air cargo density may be required to insure that future aircraft designs are aimed at the optimal volume and lift combination. Few of today's air cargo loads tax the lift capability when the volume is filled, but the increased demand for air transport may or may not result in significantly greater average densities of air cargo.

1.8.3. Conclusions Related to Scheduling

1. Through appropriate scheduling, it should be possible to blend additional dedicated air freight movements with passenger movements, in those airports where both passengers and freight are both being accommodated, without necessitating additional airport runway expansion before 1990.

2. A computerized reservation system for movement of cargo over all modes should be developed and implemented. This would be highly compatible with the independent commission agent concept to be discussed later (Chapter 3).

3. The use of demand-sensitive dynamic scheduling, as would be particularly compatible with a computerized reservation system, may serve to increase load factors substantially with no degradation of service. Such a technique might serve to reduce the problem of backhaul and would certainly contribute to increased profits.

4. Even though air freight shippers want their cargo moved at night, at least some of the cargo (35%) will have to be moved during the day to enable the air freight carrier to obtain adequate aircraft utilization, unless these aircraft can be converted almost daily for use as passenger carriers.

5. Because of the dimensionality of the scheduling and routing problems, algorithms to assist planners in such activities are more likely to be heuristic than optimizing.

1.8.4. Conclusions Related to Facilities and Operations Design at the Nodes

Delays in the system occur at the nodes, therefore the nodes warrant special attention. Containerized cargo handling at the nodes is a key to speeding up loading and unloading. Further progress in standardization of containers is indicated.

1. Alternative containerizing, loading, and storage designs should be explored to insure maximal utility of investment over the next decade in which radical changes in the air cargo industry will probably occur. For example, an aircraft elevator may be preferable to an adjustable loader for the high B-747 and the lower L-500 which may become available and offer several advantages. For some time, both aircraft may have to be accommodated, and facilities built for one may be inefficient or useless for a mix of the two.

2. Past and current automated techniques should be cataloged and analyzed in order to determine where the successes and failures have occurred in past profit-making operations. The tendency to assign all functions to machines, even where the human operator is more efficient, must be avoided. Long-term reliability and versatility may be more important than short-term handling capacity.

1.8.5. General Conclusions

The mechanisms by which a significantly different, rational air cargo system could be brought about merits further study. Clearly interfirm, inter-modal coordination is needed for deriving a single cargo organization at each airport, but the various competing agencies must somehow be brought under one evolving hierarchy, probably a trade association, in order to derive the benefits a single system promises. In the process, the incentives of free enterprise must be retained.

The trade-off between cost and time must constantly be remembered. Though the mathematics of the problem may indicate one solution, the value placed on time by the user of the system must not be forgotten.

A theoretical model of a network may be suitable for initial studies; but the analysis of a specific network of routes and terminals will yield more reliable data.

To simplify the economic analysis of a complex air cargo system, it may be necessary to optimize each phase of the network.

If the railway network in this country is revitalized, its effect on the proposed air cargo system could be substantial. The truck link and, in particular, the feeder aircraft link could be replaced by a rail link if that revitalized system is rapid, reliable, and economical.

Advances in helicopter fuel efficiency and in range could certainly make this mode of transportation more attractive for the pick-up and distribution of containerized cargo. This would decrease the use of trucks for the first and last links of the cargo movement.

No matter how sophisticated, any model which uses the forecasts of future situations is susceptible to error. Major and occasionally minor errors in estimating future demands, capabilities, and operations could negate the conclusions of an economic analysis. As a result, it is not unusual to find that "gut feelings" may give useful indications of trends just as accurately as a complex computer simulation.

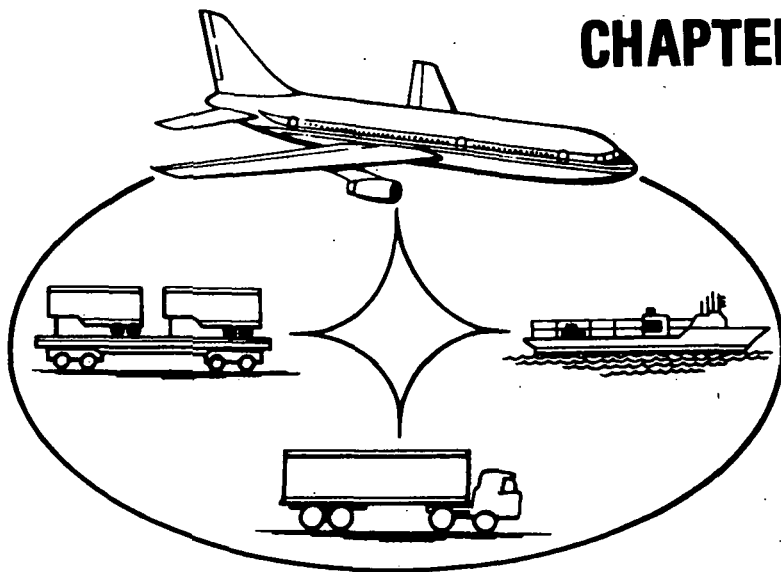
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CHAPTER 2



GROUND SUPPORT

CHAPTER 2

GROUND SUPPORT

Introduction

While traffic on the system flows through the network, it must enter that network through a ground support system. This support system includes the standard business practices used to attract cargo to the air mode, the legal and regulatory framework by which freight is interfaced between surface and air, and the terminal facilities which expedite transfer. The purpose of this chapter is to review these elements of the ground support system and prescribe how they should appear in the 1990-2015 system. It will proceed from the general design requirements of a cargo terminal, through the institutional and legal practices needed to support 1990 operations, to an analysis of the impacts of such a system. Some operating premises beyond our basic assumptions were used in this section. First, it was accepted that a number of companies would be carrying air freight at airports of any size. Hence, terminals are usually built for or by individual airlines, not to handle the total cargo volume of an airport. Second, the assumption of "no new airports" was taken literally. While new terminal facilities might be built at existing locations, the contingency of a major hub grade dedicated cargo airport was not considered. The attendant surface access problems were subsequently not addressed in a design context. Arguments against a dedicated freightport, however, were advanced. Third, the committee did not feel it was possible to offer a specific terminal design, because site idiosyncracies would preclude any acceptable general configuration. What was reported are the general elements and size of an advanced terminal facility.

2.1 CONTAINERIZATION

"In my opinion, the relationship or need for intermodality on an interchangeable containers basis between surface carriage and air freight transportation is virtually non-existent today."(ref. 1)

"Achievement of a viable large-volume air cargo service is dependent upon the use of a large unit load device . . . , and complete compatibility with the surface freight system . . ."(ref. 2)

2.1.1. Introduction

Perhaps the best way to start a discussion about containerization is to define it. This is done by the Containerization Institute in the following manner:

"Containerization is the utilizing, grouping, or consolidating of multiple units into a large container for more efficient movement."

In the present day cargo transportation industry one can find extensive use of containers. Containers of all sizes and shapes are transported by trucks, trains, ships, and airplanes. Since everyone is using containers, one might ask why all the interest in the subject of containerization? That question is best answered by Eric Rath's statement:

"Containerization is a systems approach to transport service. It represents the dawn of an era, in which all modes of transportation will be subjected to integration into a single, world wide system."(ref. 3)

The key word in this statement is integration. This should be taken to mean that a container is a container, is a container, etc. irrespective of the transportation mode used to move it.

An effort has been underway since the end of World War II to develop standardization in containers. This effort has met with some degree of success with the surface modes of transportation (highway, rail, sea). However, the air freight industry has not participated in this standardization. Thus, an air freight container is generally considered to be uni-modal, even though these containers are transported by truck between the customer and the airport.

Is the fact that its containers are uni-modal detrimental to the air freight industry?

If we return to the quotes given at the beginning of this section, we may well find the answer to this question. McNulty indicates that there is no need at present for air freight to have an intermodal container. His reason is that, since most of the air freight business is small packages in less than truck load quantities and since the standardized containers are large in size (2.44m x 2.44m x 6.1m or 12.19m), there is not sufficient demand to justify

going to a standardized container. If we look at the quote from Lockheed, we see that they suggest that sufficient demand is dependent upon intermodal air containers. We are thus left with "the chicken and the egg" problem: What comes first, the demand or the containers?

In the remainder of this section, we will examine some aspects of containerization with primary emphasis on its use in the air freight industry.

2.1.2. History

The idea of containerizing cargo is not new. It probably dates back to the days of the Roman Empire when containers (cages) were used to transport animals. However, the modern day concept of containerization got started after World War II. The first step was the use of pallets for unitizing cargo. Of course, pallets are still used extensively today. Next came the TOFC (Trailer on Flat Car) or piggyback concept developed by the railroads and the Trailers on Ships or RO-RO (Roll on - Roll off) developed by the shipping industry. Both of these concepts were initiated in the early 1950's. Note that in both cases the conventional wheeled truck trailer was used.

The next logical step was to take the wheels off the trailer thus yielding a container. By the mid-fifties, containers were being moved on container barges. Soon to follow was the containership and COFC (Container on Flat Car). With trucks and trains to move the containers over land and barges and containerships to move them over water, the freight forwarder quickly generated and sold the door-to-door service idea. In doing so, the freight forwarding industry was instrumental in the setting of standards for containers.

During the 1960's, the use of and the tri-modal (truck, train, and ship) standardization of containers soared. Even though the use of containers was also growing in the air freight industry, there was no standardization of these containers with the other modes of transportation.

2.1.3. Standardization of Surface Mode Containers

Primarily through the efforts of the International Organization for Standardization (ISO) and the American National Standards Institute (ANSI) there have evolved standards for intermodal containers. There will be no effort made here to discuss in detail these standards. Basically, however, these standards deal with dimensions, strength, and the corner fittings of containers. Figure 2.1 illustrates some of the standardized containers and Table 2.1 (ref. 4) summarizes basic data on them.

At present, in order to conform with ISO standards a container must be strong enough to be stacked six high and also be capable of withstanding the stress and strain of normal transportation conditions.

Figure 2.1 illustrates the corner fitting. For exact dimensions of the top and bottom corner fittings, one is referred to the ISO Draft Recommendation No. 1019, a copy of which may be found in Jane's Freight Containers 1969-70 (ref. 5). The corner fittings allow for standardization of container handling

Table 2.1

DATA ON STANDARD INTERMODAL CONTAINERS

External Dimensions meters (feet)	Material	Internal Volume m ³ (ft ³)	Payload Capacity kg (lb)	Tare Weight kg (lb)
2.44 x 2.44 x 3.05 (8 x 8 x 10)	Steel	15.0 (529.7)	8992.0 (19,823.6)	1340.0 (2954.2)
2.44 x 2.44 x 6.1 (8 x 8 x 20)	Steel	33.0 (1165.3)	18,040.0 (39,770.7)	2280.0 (5026.5)
2.44 x 2.44 x 6.1 (8 x 8 x 20)	Glassfibre/Steel	30.3 (1069.9)	18,320.0 (40,388.0)	2000.0 (4409.2)
2.44 x 2.44 x 6.1 (8 x 8 x 20)	Aluminum/Steel	31.0 (1094.6)	18,643.0 (41,100.1)	1677.0 (3697.1)
2.44 x 2.44 x 12.19 (8 x 8 x 40)	Steel	63.0 (2224.6)	26,880.0 (59,259.3)	3600.0 (7936.5)
2.44 x 2.44 x 12.19 (8 x 8 x 40)	Glassfibre/Steel	61.7 (2178.7)	26,960.0 (59,435.6)	3520.0 (7760.1)
2.44 x 2.44 x 12.18 (8 x 8 x 40)	Aluminum/Steel	63.0 (2224.6)	27,229.0 (60,028.7)	3254.0 (7173.7)
2.44 x 2.59 x 12.19 (8 x 8.5 x 40)	Steel	67.0 (2365.8)	26,789.0 (59,058.6)	3682.0 (8117.3)
2.44 x 2.59 x 12.19 (8 x 8.5 x 40)	Glassfibre/Steel	66.0 (2330.5)	26,880.0 (59,259.3)	3600.0 (7936.5)
2.44 x 2.59 x 12.19 (8 x 8.5 x 40)	Aluminum/Steel	67.0 (2365.8)	27,216.0 (60,000.0)	3266.0 (7200.2)

ISO/ANSI Corner Fittings

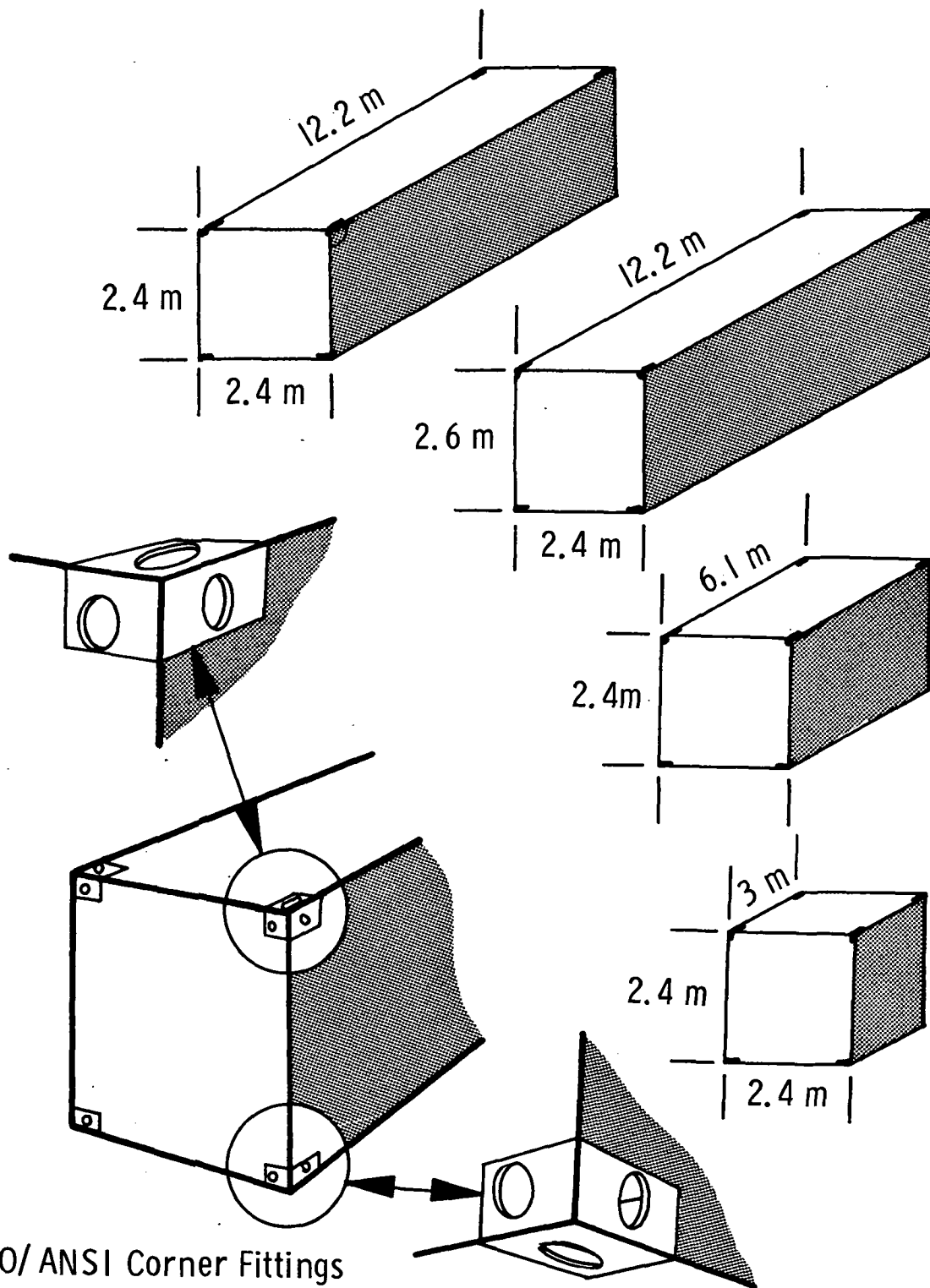


Figure 2.1 ISO/ANSI STANDARD CONTAINERS

equipment, storage equipment and tie-down fittings on the transport vehicles. Also, smaller length containers can be joined to make larger length containers. For example, joining two twenty foot containers to make an equivalent forty foot container can be done.

Even though much progress has been made toward standardizing containers, compliance with recommendations made by ISO, ANSI, and others is completely voluntary. There still exist some companies within the freight industry who do not conform to ISO standards. For example, Sea-land uses a non-standard 2.44m x 2.59m x 10.67m (8ft x 8.5ft x 35ft) container. Matson's containers are 2.44m x 2.59m x 7.32m (8ft x 8.5ft x 24ft).

2.1.4. Types, Materials, and Ownership of Surface Mode Containers

There seems to be an almost endless supply of different types of containers. Many of these containers exist for very specific needs. Generally, containers are rectangular with a width of 2.44m (8ft), a height of 1.22m, 2.44m, or 2.59m (4ft, 8ft, or 8.5ft) and a length of 3.05m, 6.1m, 7.32m, 9.14m, 10.67m, or 12.19m (10ft, 20ft, 24ft, 30ft, 35ft, or 40ft). Below are listed some of the container types presently available:

- | | |
|------------------|--------------------------|
| (1) Dry freight | (6) Tilt |
| (2) Open-top | (7) Open-side |
| (3) Insulated | (8) Flat |
| (4) Refrigerated | (9) Half-height open-top |
| (5) Tank | (10) Pressure tank |

"The materials being offered in containers vary from ultraheavy to ultralight, and from ultrafragile to ultrastrong." (ref. 3) There are a number of factors which must be considered when choosing what material or combination of materials to use in constructing a container. These factors include strength, weight, cost, maintainability, working life, and corrosion and rust resistance. The following is a list of some of the materials that are used in the construction of containers:

- | | |
|------------------------|---------------------------|
| (1) steel | (5) reinforced plastic |
| (2) aluminum alloys | (6) reinforced fiberglass |
| (3) glassfibre | (7) composite |
| (4) reinforced plywood | (8) balsa wood laminate |

As one might suspect, a container represents a large investment. Depending on the material used in its construction, a twenty foot container can cost \$3 000 or more. For the large volume shipper, such investments can often be justified. However, for smaller volume shippers owning their own containers is economically impossible. For these shippers, the answer is to lease or rent containers. The shipper may lease or rent a container from carriers, container manufacturers and/or container leasing companies. The arrangements and rates depend on such factors as length of lease, type and size of containers, and one way or round trip use.

2.1.5. Containerization in the Air Freight Industry

The use of containers in the air freight industry is not new. At present, it is estimated that between 30 and 35% of the revenue tonne-kilometers generated by domestic air freight is shipped in containers (ref. 6). This should not be surprising since the use of containers offer both the shipper and carrier advantages, such as:

- (1) They greatly reduce the processing time by eliminating the verification, weighing, checking of labels, inspecting, etc. of many individual items.
- (2) They greatly reduce the documentation required.
- (3) They reduce the chance of pilferage.
- (4) They reduce damage to the shipment. This includes ground handling, line haul, and weather damage.
- (5) They eliminate the handling of the actual cargo at the air freight facility. Only the container is handled.
- (6) They reduce the door-to-door shipping time.
- (7) If the shipper loads the container and the receiver unloads it, additional cost savings can be achieved. A high volume shipper can also save money by purchasing his own container.

There are disadvantages of containers such as high initial cost, high maintenance cost, high tare weight, and increased storage space, but in general, the advantages outweigh the disadvantages.

By the mid 1960's, air freight containers had evolved into three basic sizes. They were called types A, B, and D. There were, however, a number of problems associated with these containers.

- (1) They were not interchangeable among aircraft.
- (2) They were large and hard for the shippers to handle.
- (3) They were accessible only to jet airports since their contours fit only the jet freighters.
- (4) They were expensive for the shippers to buy.
- (5) They were fragile.

Since the average size shipment by air was 122kg (269lb) and 92% of the domestic air freight shipments were under 226.8kg (500lb) in 1974 (ref. 7), the air freight industry developed the smaller type Q and E containers in order to meet the shipper's needs. These containers were also much easier to handle.

During the development of the air freight containers, no effort was made to make them compatible with surface transportation. In more recent years, there has been an effort to develop and use containers that are compatible with the surface mode, especially trucks. At present, there are two sizes of rectangular container used in the air freight industry, the M-1 and the M-2. The M-1 is 2.44m x 2.44m x 3.05m (8ft x 8ft x 10ft) and the M-2 is 2.44m x 2.44m x 6.1m (8ft x 8ft x 20ft). Some of the current road blocks in developing air containers that are totally compatible with the surface modes are:

- (1) Tare weight: in order to have the strength necessary to stack containers six high on container ships, the containers must be constructed of materials which cause high tare weights and are thus undesirable for air freight purposes.
- (2) The ribbed construction of the bottoms of surface containers make them incompatible with the roller conveyor systems used to load and unload aircraft. These containers may be placed on pallets and rolled in and out of the aircraft but this increases tare weight.
- (3) The corner fittings of surface containers often protrude from the container bottom up to .02m (3/4in) which cause overload conditions for the floor of the aircraft (ref. 8).
- (4) There are only a few commercial aircraft capable of handling 2.44m x 2.44m (8ft x 8ft) containers.
- (5) Current air freight demand is not sufficient to justify the use of large rectangular containers nor to justify the purchase of airplanes that can carry them.

There are efforts currently under way by several organizations to standardize air freight containers. Both the Air Transport Association (ATA) and the International Air Transport Association (IATA) are working to standardize containers within the air freight industry. This effort has met with some success. There are a number of containers which have been standardized to make them interchangeable among the widebody aircraft: B-747, DC-10, L-1011, and A-300. However, there still exist some containers which are specifically designed for a particular aircraft. For example, the LD-1 container fits only in the B-747.

An effort is also underway by these same two organization, along with ISO, ANSI, and SAE (Society of Automotive Engineers), to develop standards for the rectangular intermodal containers. This effort has led to the designation of the M-1 and M-2 containers. These containers are quad-mode (air, rail, truck, ship) containers but are capable of being stacked only two high instead of the ISO/ANSI standard of six high.

2.1.6. Types, Materials, and Ownership of Air Freight Containers

As was alluded to in the previous section, there are a number of different types of containers used in the air freight industry. Figure 2.2 illustrates some of these containers and Table 2.2 summarizes specific data for them.

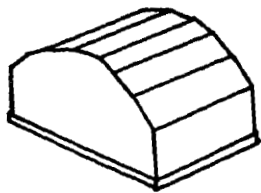
Tare weight of the air freight container is a very important factor in the selection of construction material for the container. An effort is made to achieve a tare weight of less than 24kg/m^3 (1.51lb/ft^3) (ref. 3). At present, air freight containers are made of materials ranging from corrugated cardboard to steel. However, in order to achieve high strength and low tare weight, the industry has turned to containers made of composite materials, such as balsa wood laminate, reinforced fiberglass, reinforced plastics, and aluminum alloys. Containers with a tare weight of 21.15kg/m^3 (1.32lb/ft^3) and with good strength characteristics have been obtained.

The M-2 container which is intermodal (except for stacking limitations) has the ISO/ANSI corner fittings and a smooth, flat undersurface for interface with the roller system of loader and airplane (ref. 9). It weighs approximately 988kg (2200lb) and cost approximately \$8500. (This is half the weight and three to four times the cost of the same size ISO marine container.) This container achieves a tare weight of 27.5kg/m^3 (1.72lb/ft^3) which is approximately half the 54.4kg/m^3 (3.41lb/ft^3) achieved by ISO marine containers.

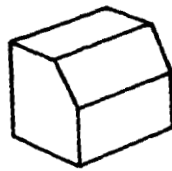
As was the case with surface container ownership, air freight containers may be owned by the shipper, the airlines, or a leasing company. In general, the larger containers (types A, LD3, LD7, LD11, M-1, M-2) are owned or leased by the airline and the smaller containers (types B, D, Q, E) are owned or leased by the shipper. In general, the larger containers mentioned above do not require additional processing by the carrier if loaded by the shipper since they are air-worthy. This is not the case for the smaller containers.

2.1.7. Cube Utilization

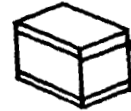
Cube utilization or stacking efficiency (ref. 11) has been a driving force in moving the air freight industry away from pallets and toward containers. Cube utilization is defined as "the percentage of the interior volume of a container that is actually taken up by the packages stowed within." (ref. 12) The lack of high cube utilization is a major contributing cause to the fact that the freight airplane usually cubes-out before it weighs-out. Simply put, this means that the cargo is not of sufficient density to fully utilize the airplane's weight carrying capability. There are two ways to prevent the cube-out problem. One way is to increase the average density of the cargo carried. However, in a 1968-69 international survey, Douglas (ref. 12) found that the average density of a cargo package was 229kg/m^3 (14.31lb/ft^3). Since the shipper decides what to ship by air and since the air freight industry is not in a position to be particular about what they accept for cargo, there is little chance that the density of the cargo shipped by air can be increased by the air freight industry.



Type A
 10.0 m^3



Type B
 5.04 m^3



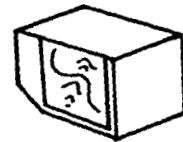
Type D
 1.6 m^3



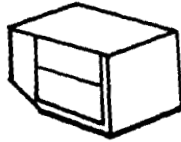
Type Q or QD
 0.34 m^3



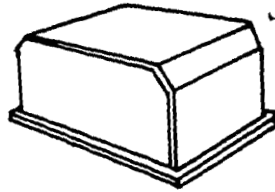
Type E
 0.459 m^3



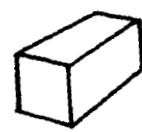
Type LD I
 4.84 m^3



Type LD 3
 4.25 m^3



Type LD 7
 10.5 m^3



Type LD II
 6.85 m^3

Figure 2.2 AIR FREIGHT CONTAINERS

Table 2.2

DATE ON AIR FREIGHT CONTAINERS

Container Type	Length m (inches)	Width m (inches)	Height m (inches)	Internal Volume m ³ (ft ³)	Tare Weight kg (lb)	Cargo Weight kg (lb)
A	3.02 (119)	2.13 (84)	1.93-1.22 (76-48)	10.08 (356)	258.6 (570)	3175.2 (7000)
B	2.13 (84)	1.47 (58)	1.93-1.14 (76-45)	5.04 (178)	149.7 (330)	1587.6 (3500)
D	1.07 (42)	1.47 (58)	1.14 (45)	1.61 (57)	68.0 (150)	907.2 (2000)
Q or QD	1.00 (39.5)	0.70 (27.5)	0.53 (21)	0.34 (12)	18.1 (40)	181.4 (400)
E	1.07 (42)	0.74 (29)	0.65 (25.5)	0.46 (16.2)	22.7 (50)	226.8 (500)
LD-1	2.34-1.56 (92-61.5)	1.52 (60)	1.63 (64)	4.84 (171)	124.7 (275)	1159.0 (2555)
LD-3	1.91-1.47 (75-58)	1.45 (57)	1.50 (59)	4.25 (150)	167.8 (370)	1406.2 (3100)
LD-7	3.18 (125)	2.24 (88)	1.60 (63)	10.48 (370)	117.9 (260)	4445.3 (9800)
LD-11	3.18 (125)	1.52 (60)	1.63 (64)	6.85 (242)	167.8 (370)	2993.8 (6600)

The second method of preventing the cube-out problem is to increase cube utilization. In the same 1968-69 survey previously mentioned, Douglas found that average cube utilization was about 54%. There were two prime reasons for this result. First, there is a lack of cargo in some cases to sufficiently load pallets and/or containers. This problem can only be solved by a better marketing and sales program. The second reason is the use of pallets which tend to be packed inefficiently in the vertical dimension. The use of containers can solve this problem. It has been demonstrated that containers can achieve cube utilizations between 88 and 93% (ref. 13).

Even though there is substantial use of containers in the air freight industry, most of them are contoured instead of rectangular containers. The contoured containers are specifically designed to conform to the inside shape of the airplane, thereby more fully utilizing the available volume of the airplane. However, there are three distinct disadvantages of using contoured versus rectangular containers. They are:

- (1) Contoured containers cost more per cubic meter of volume than do rectangular containers (ref. 12).
- (2) A contoured container is less efficient (based on cube utilization) than a rectangular container. For example, for a rectangular and contoured container each of 12.74m³ (450ft³) volume, the contoured container is about 2.5% less efficient (ref. 12).
- (3) Contoured containers are sometimes designed and built for a specific airplane which restricts the intramodal use of these containers.

2.1.8. Rectangular Container Capability of Current Aircraft

The introduction of the widebody airplane in the early 1970's was the start of a new era in the air freight industry. These aircraft were capable of carrying much more freight than the narrowbody airplane. For example, the four engine narrowbody airplane can carry 33 294-46 448kg (36.7-51.2tons) of cargo (9 435kg if carrying a full complement of passengers) while the four engine widebody airplane is capable of 113 036-119 023kg (124.6-131.2tons; 26 339kg with passengers (ref. 7)).

There are four widebody aircraft on the commercial market today. They are the B-747, the DC-10, the L-1011, and the A-300. At present there is only one widebody freighter, the B-747-F. Each of the widebody passenger aircraft is capable of carrying considerable freight. In general, this freight is containerized in the LD type containers. The cargo for these aircraft is side door loaded. The passenger aircraft, in general, do not have the capability to carry 2.44m x 2.44m (8ft x 8ft) containers.

The nose loading B-747-F is capable of handling the M-1 and M-2 containers and also the 2.44m x 2.44m x 12.19m (8ft x 8ft x 40ft) containers. The only other commercial aircraft with this capability is the L-100.

The B-747-F is the largest commercial freighter available today. It is capable of carrying up to 117 936kg (260 000lb) of cargo (ref. 7). In terms of rectangular containers, the B-747-F can handle the following maindeck configurations (ref. 14):

- (1) Thirteen 2.44m x 2.44m x 6.1m (8ft x 8ft x 20ft) and four 2.44m x 2.44m x 3.05m (8ft x 8ft x 10ft) containers.
- (2) Five 2.44m x 2.44m x 12.19m (8ft x 8ft x 40ft) and ten 2.44m x 2.44m x 3.05m (8ft x 8ft x 10ft) containers.

This airplane is limited to carrying containers with heights of not more than 2.44m (8ft). At present, approximately 97% of the domestic inventory of intermodal 12.19m (40ft) long containers are over 2.44m (8ft) in height. For the 6.1m (20ft) containers, there are approximately 47% over 2.44m (8ft) and this percentage is increasing at a rapid rate (ref. 10). These trends could hinder the intermodal capability of the air freight industry in the future unless new aircraft are designed to handle the taller containers.

A recent industry/government effort was made to demonstrate that air transportation could be completely compatible with surface transportation. The effort was led by the Lockheed-Georgia Company and was named Intermodal Air Cargo Test or Project Intact (ref. 2). The Air Force's C-5 Transport was used in the demonstration. Rectangular containers conforming to ISO/ANSI standards were used. The containers were 2.44m (8ft) wide, ranged in height from 2.44m to 4.12m (8ft to 13.5ft) and were either 12.19m or 13.72m (40ft or 45ft) long. On one demonstration flight, the airplane carried six 2.44m x 2.59m x 12.19m (8ft x 8ft x 40ft) containers. It should be noted that the airplane weighed-out instead of the usual cube-out situation.

There are presently four air carriers who offer the M-2 container to their customers. They are Seaboard World, Lufthansa, American, and Air France. There are some 400 of the M-2 containers in use today (ref. 10). There is still not a substantial volume of air cargo moving by the M-2 container, however, during the period October 20, 1976 to December 23, 1976, Seaboard World moved 963 M-2 containers between the United States and Europe (ref. 10).

2.1.9. Summary

Approximately 80% of the air freight being hauled today is either emergency shipments or physically or economically perishable commodities (refs. 7, 15). Air Cargo is primarily small packages and has a high dollar value (ref. 2). In 1976, of the approximately 24.9 billion revenue-tonne-kilometers (17.1 billion revenue-ton-miles) flown, about half went as belly cargo in passenger aircraft (ref. 14). The remaining half went to all freight aircraft. This volume is insufficient to justify many of the intermodal container concepts. The present air cargo markets are already well developed and offer little hope of substantial volume increase. New markets must be obtained. This can be done by becoming more cost competitive. One of the ways to become more cost competitive is for the air freight industry to develop intermodal capabilities. This will lead to a more integrated transportation system which will use standardized containers. The use of the standardized containers could well be

a driving force in obtaining realization of regulations imposed by world government which presently hinder good door-to-door service (ref. 3).

The bottom line is that through the use of intermodal containers, the air freight industry can become a high volume business which is economically viable, and still provide the customer with a fast, reliable, door-to-door service.

2.2 INTERMODAL ACCESS

Currently cargo arrives at freight terminals in packages or air containers. Intermodal containers of the 6.1m variety will be an addition to this mix. The access routes to and staging areas of terminals must be modified to handle the new array of vehicles which will carry cargo to the airport. The essential difference between existing terminals and those of 1990 will be the capacity to handle intermodal containers. Other problems are similar in type to those handled at present facilities; they are likely to grow as the amount of air cargo grows. Currently the only direct access provided is to trucks, the trucks often sharing major routes with automobiles. In general, the research on terminal accessibility has been limited to passenger traffic (refs. 16, 17, 18, 19, 20).

This section has four major purposes: 1) to consider the types of access required by surface modes in ACIS; 2) to consider the concepts by which this access might be provided; 3) to consider the effects of terminal configuration on access; and 4) to consider the effects of joint military/civilian use of cargo terminals on access alternatives.

2.2.1. Contemporary and Advanced Surface Modes

The four surface modes are trucking, rail, water, and pipeline. They are compatible with air transport in varying degrees. Part of the degree of compatibility pertains to the type of cargo for which each mode has inherent advantages. The greater the emphasis on bulk cargo, the less the compatibility with air carriage. Thus, rail, water, and pipeline have often been summarily dismissed as not needing air terminal access. While this is justified under current operations, some innovations may change this condition; in addition, there are some proposed intermodal hauls using air which require a better physical interface. Thus trucking will be considered on the near horizon and throughout our planning period of 1990-2015, while other modes are considered to have possible effects on the far one.

2.2.1.1. Trucking Access

Trucking access is and will be provided by highways. The major question here is how exclusive it should be. At most local (feeder) airports, the air cargo facility, if there is even a separate structure, is reached by the same roads as the passenger terminal. In some instances, a truck whose destination is the cargo terminal must pass through the entire passenger area before it arrives at the cargo gate.

Minor hub airports which, as in the feeders, have fairly simple on-facility highway networks, generally use these networks for moving both people and freight. There may be a specific turnoff to the air terminal and some staging area for trucks, however even then the primary emphasis is convenience

for personal vehicles and parking. In some instances, separate exits and access roads are provided from interstates for those with cargo terminal business. Major hub airports have separate cargo areas, hence connecting roads on the site are to some degree exclusive. Many have air exclusive cargo terminal exits from interstates or other limited-access highways leading to the facility.

The quick movement of cargo is enhanced with the exclusiveness of the cargo access routes. Trucks do not add to, nor are they caught in, congestion generated from passenger-related traffic. Clearly the greatest contributor to congestion is passenger and passenger related traffic. Access for thousands and tens-of-thousands of automobiles is a common requirement at hub airports. On the other hand, a cargo terminal with 180 tonnes per day capacity -- the volume of traffic at a minor hub -- may expect to receive only 65 trucks per day (ref. 21). While some peak-hour congestion around hubs may develop even with exclusive access roads, the problem is less severe.

2.2.1.2. Rail Access

With contemporary systems, rail access is not usually required for domestic movements. In general, commodities which can tolerate the low speed of rail transport do not need the special time advantages of air freight. The added cost is, therefore, not acceptable.

There are some international movements involving rail that, at present, do not incorporate a direct rail-air interface but could. For example, if a company in Kansas has six 6.1m (20ft) containers of their product to be exported to Japan, it is likely to travel Container On Flatcar (COFC) to a West Coast port and there be shifted to a containership, with short truck movements to connecting end point terminals. If this cargo is air eligible, a spur to the air terminal with direct transfer to a plane would facilitate the movement and increase the probability of air freight being selected for the transoceanic leg of the trip.

Currently such a movement would require trucking the containers from the railyard to the airport, stripping them, restuffing cargo into air containers, and loading the containers on a plane. This handling would probably make the air option both inconvenient and expensive. Simple transfer from a rail spur would make air transportation more competitive. However, a regular and relatively high volume of traffic would be needed to support the tracks. They would be located only at the largest hubs, probably with a coastal location.

At least one future rail concept might efficiently use access to air cargo terminals, the TRAILS system (ref. 22). TRAILS is designed to carry high value, low density cargo in small loads (39 tonnes or less) at average speed of 5.374m/s (120mi/h). It would obviously be competitive with domestic airlines for cargo, however, it may be complementary with major international hubs for single waybill movements of overseas cargos. Currently, the TRAILS system is conceived to use standard gauge track, with rationalized vehicles, and be routed in the medians of interstate highways.

Though it is questionable that such a system will ever be constructed, there will undoubtedly be some renovation and changes in operating procedures which will allow for faster and/or express COFC service between points with rail terminals. Some provision for rail access to international airports may be appropriate for both cargo and passenger traffic, if rail service is improved and highway transportation becomes more costly.

2.2.1.3. Water Access

There is no need for interface between inland waterway and air cargo facilities. The types of cargo moved in the two modes are not compatible. If an "air bridge" concept (ref. 23) is put into operation, there may be some consideration given to ocean-going container docks on the airport site for direct transfer of containers. An intermediate truck link, however, is more feasible. The container docks could not be justified even accepting stupendously high estimates of air bridge traffic. It remains that no direct access is needed for waterborne commerce.

2.2.1.4. Pipeline Access

Again, the types of cargo which traditionally move in pipeline are not compatible with the air mode. As long as liquid bulks and gases remain the major cargos, this condition is not likely to change. Some have suggested either pneumatic or hydraulic tubes for the surface transport of modules with air eligible cargo.(ref. 22) The implementation of either of these innovations would be at the end of the planning time period at the earliest, hence it is not envisioned that pipeline access to air cargo terminals should be provided, with one exception. If a terminal configuration which involves breakdown and assembly of local traffic at a remote site is selected, some sort of tube connecting the on- and off-site facilities may be feasible. This, however, is not an access problem. It is one of the terminal design.

2.2.1.5. Summary

It remains that the major ground mode of transportation needing access to air cargo terminals over the period 1990-2015 is trucking. The nature of rigs is expected to change from semi-trailers to two and three trailer types in interstate trucking by 1990 (ref. 22). This will call for some access road and staging area design modification, but the predominant interface with trucking persists.

Some interface with rails for COFC or TRAILS cargo may be needed for direct international movement at major hubs. This still is likely to constitute a small proportion of air traffic and a small space dedication in the total terminal.

2.2.2. Access Design Concepts

There are two basic access design concepts: 1) on-port access only, and 2) on-port and subsidiary terminal access. The subsidiary terminal configuration alternative pertains only to local trucking traffic. Clearly the

container transfer among planes would not be facilitated by an off-site subsidiary station.

2.2.2.1. Concept Alternatives for Trucking

Terminals can take two basic configurations on port: 1) a single building, or 2) gate arrival terminals (ref. 24). The primary advantage in gate arrivals, assuming they are assigned by region of destination, is a forced sorting of cargo before it arrives at the terminal. This saves at least a general destination classification on the premises. In physical structure and operation, these gate terminals do not vary widely from a normal terminal. They are, however, scaled down in size to the smaller proportion of cargo which will pass through each facility with the associated diseconomies of scale.

Access objectives are similar in each case. First, the staging area and bays must allow for maneuvering vehicles, dropping trailers, and transferring containers. Second, there must be adequate space for queuing of vehicles. Their arrival is a random process, hence queuing space must be geared to peak possibilities to avoid periodic congestion of access routes. Third, there must be an adequate number of bays to minimize queuing in staging area. Fourth, delays due to congestion in access routes should be minimized.

2.2.2.2. Staging and Bay Design Requirements

The nature and size of staging areas required for the types of cargo moved in an advanced system would vary by airport classification, i.e., hub, minor hub, or local airport. A hub is viewed to be a major origin and destination for domestic and international cargos as well as an important transshipment point. A minor hub is a substantial traffic generator with some transshipment, primarily in package cargo. A local airport is a generator, usually minor, of traffic. It does limited sorting and no consolidation.

2.2.2.3. Major Hubs

Considerably greater truck staging area than exists in current designs will probably be necessary for hub terminals in the 1990 advanced system. Maintaining the assumptions that substantial line-haul trucking will be done in double- and triple-rigs and recognizing that major hubs will generate foreign and domestic traffic from fairly large catchment areas, it follows the direct terminal access for the doubles and triples is desirable. Because the trailers must be dropped and brought to bays or other cargo handling areas one at a time, both larger and differently aligned staging areas are required compared to those for semi-trailers.

The triple-rigs would be the largest access vehicles expected. Most vehicles going to the cargo bays in the package terminal would remain local delivery trucks. The current estimate of 558kg (1230lb) payload per truck entering or leaving cargo terminals would probably apply to these vehicles. Double- and triple-rigs would carry substantially higher payloads. A 180 tonne terminal, one large enough to handle the full volume of a domestic hub

or each of several carriers in a hub with international traffic, could handle 624 vehicles in the bays in a 24-hour period.

This assumes 13 bays in the covered package area and an average of one-half hour in a bay for each vehicle. Assuming a 2300 to 700 hour curfew on aircraft take-offs and landings at the airport, hence a 600 to 2400 hour operation of the terminal, 468 trucks carrying traditional package cargo could be handled at the terminal building. Current designs for terminals of this 180 tonne average capacity include 13-16 cargo bays (ref. 21), hence would need no modification to conform to this projection. Holding area, however, may be limited to as few as three additional parking places for 12.2m (40ft) semi-trailers. This holding area is approximately 166m² and is inadequate for the size and operation of double- and triple-rigs.

Because the multi-trailer rigs must drop all but one of their elements to maneuver into bays, there is at least one trailer in holding for every one being stripped or stuffed. Thus it is conceivable that a holding space will be required for each bay in addition to those spaces for rigs which have no elements in the bay. Each of these spaces will occupy a greater area than those designed for semi-trailers. In addition, queuing space will be needed for the local delivery trucks.

The holding area needed for trucks alone should be 540m². This amount of space would allow for holding 48 triple-rigs, or more vehicles of smaller sizes. This is approximately three times the area of the bay space plus three overflow parking places. It would be possible to have 13 triple-rigs being loaded or unloaded and 13 full plus 13 empty ones in queue.

Space for a 6.1m intermodal container operation must also be provided. Current maritime container facilities have about 81 000m² reserved for each container berth. This, again, follows the rule of holding three times the capacity load of associated container ships and provides working space and full plus empty container holding areas. Nowhere near this allocation will be required on an air terminal, because the capacity of an air freighter is so much lower than that of a containership. Allowing for a possible load of 18 of the 6.1m (20ft) boxes in a Boeing 747-11F/111F, (ref. 23, 25) the largest proposed incremental improvement in craft size over current wide-bodies, 8100m² would be a generous allowance of staging area for such cargo needs. This would include the storage for equipment, space for the bay, and a truck holding area. It is approximately five times the space needed for the load from a single craft.

Gross staging area, not counting terminal structure bays, can then be expected to be on the order of 8600m² to accommodate the interstate truck of the 1990's. This is a spectacular increase in open storage and holding area. There is also some inherent overcapacity. The payload of a single 747-11F/111F would be on the order of 110 tonnes, 77 in the main deck containers, and 33 in the belly. This assumes an average cargo density of 107.3kg/m³, and is posited on a trans-United States or East Coast U.S. flight to Europe with a craft whose capacity is 130.5 tonnes at that stage length. All cargo is containerized with 9 standard intermodal 6.1m boxes, 9 M-2 intermodal containers, 4 of

the 3.05m boxes, and 40 LD-1 type belly pods. The payload of two dedicated flights would exceed the average daily volume of the covered facility. Such a terminal would probably be minimal to allow maneuvering and avoid the queuing problems associated with access, however, it would be capable of handling substantially greater volumes if containerized service was highly successful. Eight such flights daily would allow the processing of approximately 880 tonnes of containerized freight, 265 of which would be in the belly.

The belly containers could derive from package cargo which has been consolidated on- or off-site. These would be processed through the regular terminal structure, hence holding space for cargo or trucks accessing it would not be needed at the intermodal container berth. Most of the 6.1m containers would arrive two at a time on flatbed trucks; an average of two per vehicle can be assumed. A 24-hour operation with two hour turnaround for the aircraft, i.e., two hours to strip, stuff, and fuel the craft, would generate 216 trucks. Holding area for vehicles would be provided for within the 8100m². In a major hub port, several carriers may require this sort of minimal holding and staging area. Considerable construction cost and ground area might be saved if a number of terminals used common staging areas. This would also mitigate the extensive overcapacity.

Finally, some provision for parking for those sending and receiving freight is necessary. Forwarders, brokers, and other principals will need to be on site for customs and to receive cargo in major hubs. Small package pick-ups and drops may be done by personal vehicles. The amount of space needed for parking depends greatly on the local infrastructure and volume of traffic hence will not be detailed here. The space required will increase as the number of shippers and intermediaries grows.

Some special consideration may be needed in terminal design for increased volumes of cargo which has been consolidated into belly containers off the port by forwarders. As was noted earlier, freighters which are designed to move the 6.1m intermodal container also have considerable belly hold capacity. Both increases in large dedicated freight and in passenger fleets result in increases in belly cargo capacity; hence the total space available for cargo in the belly holds will almost certainly increase at greater rates than that for cargo above decks.

Forwarders who handle small lots are likely to take advantage of this condition. The LD-1 containers, used in the earlier computations, can carry approximately 540kg (1200lb) of cargo at 107.3kg/m³. Using these containers for small lots would avoid waiting to fill a full 6.1m box, and hence expedite service. Assuming 40 percent of the traffic continues to derive from forwarders, increased handling of full belly containers can be anticipated. Special bays for the receipt and delivery of them will facilitate access and operations.

2.2.2.4. Other Mode Access for Major Hubs

Trucking and rail are the only two modes which would require direct access to terminals in the 1990 period. Accepting the premise that double-and

triple-trailers will be handled directly from interstate highways, the need for the earliest possible separation of trucks from passenger terminal traffic is emphasized in hub ports. The traffic capacity of these freight access roadways would vary according to the total airport traffic, the exact terminal configuration, and the mix of intermodal containers compared to other types of cargo. Using the figures calculated for the earlier analysis, a 24-hour capacity operation would generate 840 trucks, 216 of which would be at least semi-trailers. This is an average of 35 vehicles per hour (this rate is the same for the curfew-limited example). Personal automobiles with business at the terminal would also add to the load. A two-lane, two-way highway would be adequate to handle this sort of load with terminal staging of the type outlined above. At a major hub, where ten or twenty such terminals might exist, a four-lane road would be necessary.

For rail, a single track with three spurs should be adequate to handle any anticipated needs. Each spur should hold 4 to 6 COFC, the approximate payload of a large dedicated freighter. This configuration follows the marine berth storage capacity of three times the containers in a single vessel. Insofar as airports are located some distance from switchyards or mainlines, there may be problems encountered in acquiring the right-of-way for a rail spur.

2.2.2.5. Minor Hubs and Local (Feeder) Airports

No substantial changes in access links and staging areas are needed to install the 1990 advanced system where most minor hubs and local airports are concerned. Localized assembly and distribution will still be by truck, and the trucks involved will not be the double- and triple-trailer interstate rigs. While some volume increases, hence terminal expansion, can be anticipated, the basic access rights-of-way and staging areas can remain as they are in higher volume cargo ports of today. The single exception would be a terminal which originates a regular container traffic. Here container handling equipment and holding would have to be provided. Few of the minor hubs or locals would have this traffic.

2.2.2.6. Off-Site Assembly and Distribution

The development of satellite terminals for local assembly and distribution of goods must be considered in the light of scale economics of terminal size. The off-site terminals do not eliminate the need for on-site facilities, they merely modify the latter to container processing terminals with regard to localized traffic. The on-site terminal at hubs must still consolidate and breakdown cargo for transshipments. With hubs, then, both the on- and off-site facilities do assembly and breakdown of cargo; in addition, the on-site terminal processes full containers.

Only in local terminals could the port and satellite stations have distinct operational characteristics. In this instance, however, it is unlikely that the volume of traffic would justify specialization of function and ground crews. In hub ports, since the on-site crews will have to perform all the functions of off-site ones plus more, the feasibility of a satellite is based

on the volume of local traffic as a proportion of total traffic. If the transshipment far exceeds the local traffic, all cargo should probably be handled on-site, otherwise there are strong possibilities of overcapacity, i.e., inefficiently used labor, at the port.

Before a remote assembly point should be considered, the volume of local traffic needs to be high enough in itself to justify a terminal, and the ratio of local to transshipped traffic should be high. There is also an additional transfer cost from the satellite to the main terminal which must be integrated into the costs of such an operation. Finally the location of the remote terminal must be selected.

Algorithms have been proposed for this location problem (ref. 26), and there are a variety of general location-allocation techniques which pertain. Terminals could be located to minimize total surface transportation costs or time to trucks, to equalize surface transport costs or time to consumers, to minimize the cost or time to the most remote consumer, or to satisfy other criteria. Some algorithms incorporate established networks; others assume direct point-to-point travel. All allow that any location within the space delimited is eligible for terminal placement.

In reality, there are considerably fewer possible sites for a remote terminal. The possible locations are limited by zoning. Such a terminal could be in only those classifications in which industrial activities are permitted. In all likelihood, old interior manufacturing districts would have considerable access and internal circulation problems, hence would be unsuited to a freight terminal. Planned manufacturing/distribution parks tend to be located on the fringes of the urban area with convenient access to interstate highways. Thus an assembly point on the airport itself would be as attractive for cost minimization as one in a new industrial park. It is highly unlikely that satellite terminals will be a practical feasibility for any single airline.

2.2.2.7. Gate Arrival Terminals

The primary problem with gate arrival terminals is the abrogation of scale economies in operations. They could be feasible only at high volume major hubs even with an expanded 1990 traffic. Further, if it is assumed airlines that will maintain separate terminals, even the major carriers do not have, and are not likely to have by 1990, the volume of traffic to justify gate arrival terminals. Gate arrival terminals would have to be used commonly by all lines to be feasible. While gate arrivals pose no particular problems for access to other modes, they are an alternative which is highly unlikely due to institutional constraints.

2.2.2.8. Access at Joint Civilian/Military Ports

The same modes would require access by the same means to airports handling joint civilian/military and civilian cargos. In some sense, the problem is minimized if military ports are used for dedicated air cargo movements. There would be no overlap with commercial passenger access. On the other hand, many

of the possible military bases for such joint use do not have the interstate and rail links needed for hub traffic. The role of such places would be to facilitate large local movements, possibly from a limited number of firms.

Using civilian airports for the loading of most routine military shipments in the United States implies no unusual access problems. However, the shipment of outsized military cargos would call for special load capacities in holding areas and on access roads. Civilian air shipment of such cargo cannot be expected to justify these additional requirements. Hence there are some access limitations on both the civilian use of military airports and the military cargos which might move through civilian airports.

Using military airports as all freight operations creates a considerable problem of interface between the cargo system and small package and belly pod traffic which originates from passenger flights. This same problem exists if any dedicated freightports are established.

2.3 TERMINAL OPERATION

A very important element in the proposed air cargo system is the airport terminal. Most of the transit time for the majority of door-to-door air cargo shipments is used on the ground and hence the weak link in improving overall service is the ground support system. The main objective of the terminal operations, then, is to achieve time savings and incidently lower the packaging costs, better the protection of the goods, and better intermodal exchange. This requires the introduction of automation and mechanization particularly in those elements of the terminal where cargo is loaded, unloaded, and moves on the ground. It also requires streamlining the consolidaton and break down operations and moving them to the ends of the distribution system, preferably to the locations of the consignor and consignee.

The terminal receives small loads, consolidates these into large unit loads which are then loaded onto the transport aircraft. On off-loading the aircraft, the terminal also receives large unit loads which are then broken down into individual parcels for delivery to the customers. Planning for the air cargo terminal then is like planning for any freight processing facility except that the large tracts of land required come from usually expensive airport land. As air cargo continues to grow in importance, the surface vehicular traffic accompanying a large volume of air cargo will require careful planning as already mentioned.

Air cargo facilities are influenced by many other factors such as surface access, the split between full freight and belly cargo, aircraft types, the split between domestic and international cargo, types of cargo, cargo handling and storage, volume of cargo, intermodal containers, the information and documentation process, airport capacity, and existing passenger traffic. This section considers four major questions for terminals of the integrated cargo system proposed:

- 1) Where should the cargo terminal be located?
- 2) What size should it have?
- 3) What should the design look like?
- 4) What loading facilities and equipment are required?

2.3.1. Locations of the Terminal

Where should the cargo terminal be? Again, many factors influence this decision, such as an existing airport versus a new airport, surface access, runway access, location of the passenger terminal, zoning criteria. The limited capacity of existing airports can be increased if certified freight forwarders handle a larger share of the small package traffic and move their assembly/disassembly areas away from the airport. The problems of the vehicular traffic associated with the forecasted growth in cargo volume will tend to

reinforce this trend to off-airport consolidation. Direct access from the runways to the cargo terminal for the aircraft and transit ways from the passenger terminal(s) to the cargo terminal(s) must be provided. Belly cargo will account for 50% of total cargo making the transferability from the passenger terminal to the freight terminal of considerable importance.

2.3.2. Size of the Terminal

How large should the cargo terminal be? That depends on many factors, such as cargo tonnage projection, airport capacity restrictions, containerized cargo storage requirements, livestock, mail, staging area, consolidation space, express service, security, and automation of cargo handling systems. The prime objective of air carriers is to fill their aircraft and this objective would be advanced by offering favorable bulk rates to forwarders, hence diminishing their own small package business. Rather than develop off-airport cargo handling facilities, they should make it clear that shipping small packages via forwarders saves time and money. A containerized system would require a proportionately smaller cargo terminal although this may be offset by the penetration into less time sensitive products requiring greater storage on the terminal. One LCA requires 10 000m² of floor space, hence a two dock operation would require at least double that area. Storage time must be cut to a minimum to maintain these space estimates, thus the interface with the trucking at the terminal will be critical. High rise storage seems the only other alternative to devoting massive proportions of the total airport to freight terminals, if transfer cannot be effected with speed.

2.3.3. Design of the Terminal

The design of future cargo terminals depends on factors such as aircraft design, the degree of mechanization and automation in cargo handling, the degree of computer control over information and documentation, and the degree of containerization. The greatest impact on the design of the interface between the cargo terminal and the aircraft is due to the introduction of the large nose loader specifically designed to carry freight. Currently civilian freighters are almost all modified passenger aircraft. The terminal must be completely mechanized to bring the containers from the truck to the loading device of the aircraft, and computers, real time teleprocessing ones, must eliminate the paper work and decisions which tend to staff a smooth flow. Momentary storage by destination in between arrivals and departures of aircraft can be handled by the same computer.

Figure 2.3 illustrates the layout of the terminal. As was pointed out in the section on rail access, there is at present no true intermodality between rail container and aircraft. This makes the air option both inconvenient and expensive. For efficiency with large volumes of air cargo, the container used therein must eventually become intermodal. In the mean time, for true intermodality, an "auxiliary" tray system is suggested in which the ISO/ANSI container with its ribbed bottom and protruding corner posts is set in a tray at the cargo terminal and automatically locked in place. The system would incorporate fixed overhead cranes to move containers from flatbeds onto terminal conveyers. At the conveyer interface, there would be a guide structure

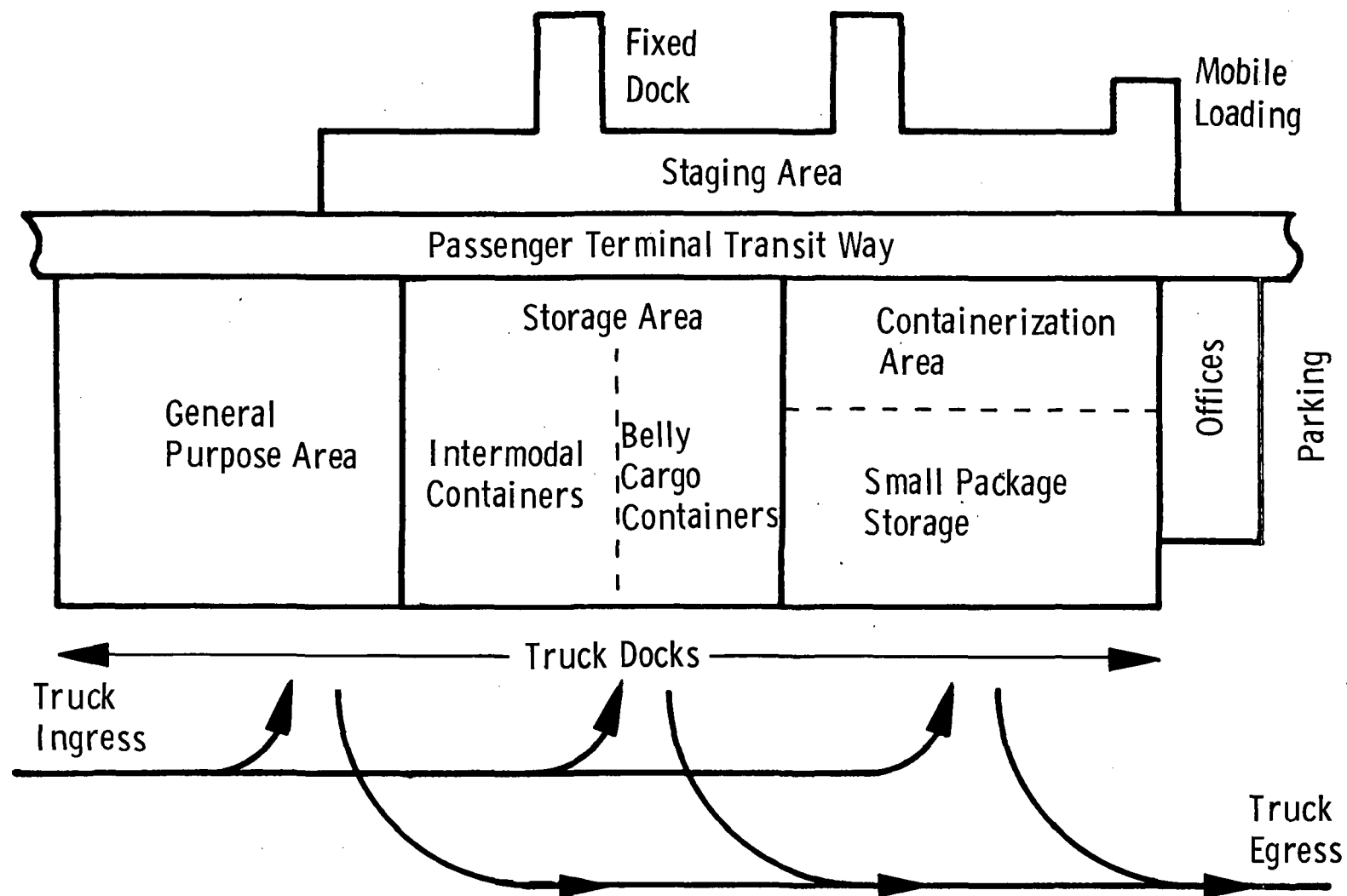


Figure 2.3 TERMINAL LAYOUT

for containers and a feeding mechanism for trays. The container and tray then move through the system in the same way as aircraft containers.

2.3.4. Loading Facilities and Equipment

The loading facilities include fixed and mobile aircraft handling units. In the fixed handling unit, the loading facilities are fully integrated with the terminal building and the aircraft taxis directly to the loading dock where a telescoping bridge raises and tilts to mate with the aircraft doors and the loading platform. From there on, the terminal handling equipment must be able to operate at the speed with which the aircraft unloads its pallets and containers, that is, at a speed of roughly 0.3m/sec, so as to take full advantage of modern methods of dealing with freight on the ground. These include standard size loading units, mechanical handling and locking, good coordination of flow inside the aircraft and on the ground with the aim of minimizing the combined loading and unloading times to something of the order of one or two hours total. A design feature of the fixed docking facility is a staging area that can move cargo to the aircraft either directly from a truck or from the cargo unitizing area. Cargos consolidated off-port need not pass through the freight classification facility. The truck offloading crane must place any ribbed bottom container on a tray. Automatic attachment between tray and container takes place before convey or transport through the terminal. The reverse process takes place when containers are removed from temporary automated high rise or horizontal storage and put on a truck.

Mobile handling equipment takes the cargo load to the aircraft at some arbitrary point on the apron, and can be used in periods of extremely high freight traffic or to handle loads from craft incompatible with the fixed docks.

2.3.5. Summary

As shown in Figure 2.3, the air cargo terminal consists of the following systems and facilities.

2.3.5.1. Aircraft Loading Area

Here a loading dock and moveable bridge are connected to a double tier staging area providing temporary separate incoming and outgoing cargo storage. The fixed dockbridge system is capable of loading and unloading aircraft through the nose or side doors while the mobile handling aspect would be served by K-loader equipment.

2.3.5.2. Passenger Terminal Transit Way

This links the passenger terminal(s) to the freight terminal with access to main storage area to containerization area as well as the staging area. This could be part of a central distribution system forming the heart of the cargo terminal as it transported cargo in all its configurations to storage areas, containerization areas, loading and unloading zones.

2.3.5.3. Containerization Area

This covered area is used for cargo buildup and break down including storage for mixed general cargo arriving from the truck docks or awaiting pick up by small package delivery trucks. This area will diminish in importance with respect to the overall terminal as the airport rises in the terminal hierarchy toward hub status.

2.3.5.4. Storage Area

Intermodal containers as well as large packages offloaded from trucks are stored here. High rise storage racks capable of handling all containers could be used to minimize the floor area. A large part will be occupied by the belly cargo containers of the passenger aircraft.

2.3.5.5. Special Purpose Area

This area can be used for special purposes such as oversize cargo, live-stock, and cold storage.

2.3.5.6. Administrative Area

The offices for the airlines, customs, and other services are housed here with separate parking facilities so as not to interfere with the delivery truck flow.

2.4 CUSTOMER COMMUNICATIONS

Introduction

No matter how effective a terminal operation is, it does not directly increase traffic moving on the air cargo system. It can lower the costs of transport, but customers must receive this information from somewhere if they are to respond by increasing their use of air cargo. The institutions, laws, and techniques by which information about freight movements is obtained, stored, and reported are, thus, integral parts of the total ground support system. This section will review these elements, particularly the marketing of air freight, the role of the forwarder in attracting and handling cargos, and the advantages of one-carrier waybills to ground support.

2.4.1. Customer Communication Service

Customer Communication Service (CCS) is the term we will use to describe the flow of information between the air cargo carrier and the customer (con-signor). Its major goal is to maintain and increase the volume of cargo shipped by the carrier. Subsidiary goals which support this are:

- 1) Expediting customer shipments to satisfy the customer and to meet service standards
- 2) Maintaining satisfactory relationships between the customer and the air cargo carrier
- 3) Keeping air cargo carrier management information on matters affecting customer relationships.

The following activities are part of CCS:

- 1) Providing the customer accurate, timely information on tariffs, schedules, classifications, and packaging
- 2) Answering queries from the customer and consignee on location, status and expected time of arrival (ETA) of specific shipments
- 3) Persuading shippers to increase their use of air cargo
- 4) Receiving and arranging action on customer requests, complaints, and directions
- 5) Advising management on matters arising from CCS activities
- 6) Handling advertising public relations and media relationships.

Any procedures or equipment used to support these activities contribute to CCS.

2.4.2. Marketing Air Cargo

The type of marketing which increases volume generally revolves around activities 1, 3, and 6. There are several steps in this marketing process.

The first step is identification of air eligible products which are produced and shipped in large quantities in the area. The next step is to determine which shippers have the biggest volume of the air eligible products previously identified. The third is to contact those shippers identified as good prospects to convince them that air cargo will be more profitable than their present mode. The fourth step is to get the shipper to sign an agreement for air cargo service. The last step is the follow up to solve any problems which may have arisen and to verify that the shipper received the service he was sold. Airlines have not been successful in effectively executing all these steps.

While air eligible products have been identified by a number of NASA contractors and, presumably, within the market research sections of airlines, the air freight industry has had uneven success in establishing and communicating attractive tariffs.

Salespersons have even closed agreements with major shipping firms using outdated tariffs which were lower than contemporary ones. For example, the CAB denied WITS Air Freight, a Seattle-based air forwarder, an exemption for mistakenly charging a Miami shipper rates based upon a canceled tariff. The Board cited an exemption in the matter would encourage other carriers to request for exemption in similar action (ref. 27). Errors of this sort have hurt the public posture of the air freight business.

Activities 2 and 4, answering queries and handling consumer requests, can be facilitated by computer technology. The data systems of Air Canada (ACCESS) (ref. 28), or Emery's Air Freight are capable of tracing the status of freight on any mode of transportation within the system within 10 seconds. In tracing cargo shipped through Emery Air Freight, both the location and status of the cargo can be obtained with the airbill number or the name of the shipper and consignee. Both the Emery and ACCESS systems are capable of printing notices to the destination port, where governments honor them to speed the cargo through customs. Very little time, if any, is lost on documentation and the tracing and monitoring are reliable.

The fifth activity, informing management on CCS matters, is, of course, an in-house activity.

2.4.3. Marketing and Personnel

Almost every employee of an air cargo carrier communicates with customers as part of his or her duties; however, this section concerns the employees who spend all or most of their worktime dealing directly with the customer. Normally, there will be at least two categories of customer service representatives (CSR) -- inside and outside representatives. The functions of the inside CSR are:

- 1) To answer customer requests for information on tariffs, schedules, service, packaging, and similar matters
- 2) To answer their requests for information on specific shipments and relay their requests for action on a specific shipment to the proper individual
- 3) To encourage increased use of the carrier's air cargo service
- 4) To inform his supervisor as directed of any pertinent information obtained
- 5) To have a CSR available to the customer during working hours.

The functions of the outside CSR are:

- 1) To call on present and potential customers to persuade them to increase their use of the air cargo carrier's services. This requires sales ability and a thorough knowledge of air cargo advantages, services, tariffs, and packaging.
- 2) To respond in person to customer complaints and requests when a personal call is justified.
- 3) To represent the air cargo carrier at meetings, service clubs, and public groups.
- 4) If the carrier has no one specifically assigned to dealing with advertising media, act as the carrier's advertising manager.

Either the inside or outside representative can be the first contact that a potential customer has with the air cargo industry. It is extremely important that they be effective in this capacity.

There are several critical areas in the large air freight forwarding business that require expertise on the part of the salesperson. One such area is knowledge of containers types, capacity, ownership, shipping modes (i.e., A1 freighters, LD-3 widebodies, and QD standard bodies), allowable tare weight and handling features for shippers. Knowledge of what cargo can be priority one (First Freight of United) is required of all forwarders. Priority shipment carries a guaranteed boarding on-line transfer and a refund if commitments are not fulfilled.

Unfortunately, especially within the air freight divisions of large airlines, the development and quality of the salespersons holds a low priority in company goals. This low priority stems from the "by-product philosophy" of air cargo transportation. The by-product philosophy regards passenger traffic as the main business of the air line. It assumes that the air carrier would not operate to carry cargo unless the carrier also transported passengers. In air carrier accounting, all or almost all indirect costs can be charged against passenger traffic; only the direct operating costs of cargo service are charged against air cargo. Little or no indirect or general overhead expense is allocated to air cargo.

In essence, the entire function of the air freight department is to fill empty holds on passenger planes. While any additional revenues which can be gleaned this way are welcome, the suggestion of investments to maximize them is met indifferently.

There are at least four areas in which marketing for air cargo can be persuasive. These include:

2.4.3.1. Market Dominance

Market dominance may be defined as a market position which brings the holder the leadership position in pricing, product characteristics, marketing channels, customer financing, and other areas. For example, an independent phone company must make its equipment and accounting compatible with that of the Bell System, the market leader. Bell dominance extends to the color of the yellow pages and of the blue public telephone signs. The market dominant firm is usually the one with the largest share of the market for the product within the marketing area. Market dominance also has a time factor. The first firm in a market has the lead in the race for dominance and in the struggle to keep ahead. Air cargo can be instrumental in attaining early market penetration and in holding the lead.

2.4.3.2. Customer Service

Another strong motivation for using air cargo is improved service (shorter delivery time) to the customer. It has the advantage of easy measurement of the elapsed time from the consignor's shipping dock to the consignee's receiving area.

2.4.3.3. Budget

Many transportation decisions are made on the basis of a transportation expense budget set by management. The traffic or shipping manager must keep his transportation expenditures within his budget regardless of service, delivery time, profitability, or other factor.

The procedure separates the transportation mode decision from the decision-maker concerned with profit, overall cost, sales, or customer service. It also tends to encourage cheaper modes such as trucks over air cargo.

If transportation manager is limited in his modal choice by a strict budget, the customer service representative should try to reach the decision-maker who can authorize use of air cargo.

2.4.3.4. Deadlines

Much use of air cargo is to meet deadlines. It doesn't matter who sets the deadline or whether the deadline is necessary or rational. If the shipping manager is told to meet a deadline, he will ship by air if this will meet the deadline and if he can rely on the air cargo carriers ability to meet its schedule. This motivation will apply to non-profit and government organizations as well as to private business. A company may advertise its use of air cargo in the hope of increasing its clientele.

There are some modeling techniques which airfreight salespersons can employ in dealing with prospective customers, e.g., the Air Freight Decision Tool (AFDT)(ref. 29). The AFDT is used to help the shipper analyze his air transportation cost. The cost of shipping by air is compared to that for other modes through a modeling procedure. The variables used are value of the

product, density of product, start-up cost, and warehouse cost. A curve showing the break even point for transporting by air is among the products.

A problem in using these total inventory approaches is that the transportation manager of a company, the individual most likely to be contacted by an airfreight salesperson, may not have control over the inventory procedures of a company. His decision to use airfreight is based totally on his budget which covers only the transfer of goods and does not include costs of warehousing, etc. Thus, an appeal to a high level of management may be necessary to sell the use of air service, no matter how evident its advantages are.

The area of advertising is also one in which approaching the proper audience is critical. Most companies find that using an advertising agency is more satisfactory than doing the whole advertising job in-house. The agency's fee normally comes from a commission, according to which media are used. Thus the air cargo company would save little or nothing by not using the agency. In addition, a good advertising agency will have skills and contacts difficult for the air cargo company to acquire and maintain.

In what media should the air cargo carrier advertise? Some suggestions are:

- 1) Trade journals of industries producing air eligible cargo. Regional journals in the carrier's area are preferred if available. National journals are more expensive and have many subscribers in regions not served by the air cargo carrier.
- 2) Trade or professional journals directed at transportation managers.

The following are not usually successful because of the high cost per prospect:

- 1) TV, radio, and general circulation newspapers
- 2) Financial, commercial, and business general papers and journals
- 3) Trade journals of industries producing non-air eligible goods
- 4) General business periodicals

There is clear room for improvement in the manner in which airlines, especially airlines whose major business is passengers, organize and execute their customer communications services. Many of these improvements lie in giving more attention to freight operations. Others may derive from delegating certain of the CCS to other parties, i.e., the air freight forwarder.

2.4.4. Air Forwarders

If an advanced large air cargo (LAC) system is to become a viable enterprise, the freight forwarder/broker must assume the role of the central nervous system for the network. The justification given freight forwarders in 1955 by the CAB is just as appropriate today as it was then, "... It

is in the public interest and need for, the service of air freight forwarders has been sufficiently established to justify the authorization of air freight forwarder."(ref. 30) The importance of the forwarder is supported by the CAB Files (Forms 244, schedule T-1) which listed freight forwarders as being responsible for tendering approximately one-half of the total freight to domestic trunk, all cargo and local service (ref. 31).

The objective of freight forwarders for the large air cargo industry of the 1990's will be to establish a one-carrier responsibility that will move cargo from dock-to-dock in a minimal amount of time, at a minimal cost to the consumer, with dependable and consistent service. The shipper would simply call the freight forwarder with a description of cargo, the time of shipment, and the destination of the shipment in question. The forwarder would be responsible for the cargo until it reached its destination. The achievement of this objective would mean that freight forwarders would offer shippers of large air cargo the same service that travel agencies offer air passengers and present freight forwarders offer for small packages service.

In designing a large air cargo system with dock to dock service for the 1990's, we must review the present state of the art. The new system may be a closed enterprise like Federal Express or it may be a forwarder with ground transportation who buys lift from commercial airlines.

-There are several advantages that operations like Federal Express have:

- 1) Since 1972 the Civil Aeronautics Board ruled that operators flying aircraft with payloads of 1500 pounds or less could be classified as "air-taxi" operators. This classification allows them to fly to any city in the United States without having to file for a certificate of public convenience or need (ref. 32).
- 2) Federal Express owns its own ground carriers which allows it to do its own pick-up and delivery. This feature allows them to offer next day, door-to-door service to any city in which they have a branch office. Since only Federal Express personnel handle the parcel, they are able to account for it at any point.
- 3) Federal Express or any other small freight airline can plan their schedule for next day service, which prevents what Art Bass describes as, "Packages from being slaves to when and where the commercial carriers wanted to move people, which just may happen not to be where the parcel is going."(ref.33)

Federal Express has several other innovations that enable them to offer next day service. One is the STAR System (Systemwide Tracking and Recording). The STAR System has three major benefits to the company:

- 1) It allows Federal Express officials to know where a package is at any given time.
- 2) It minimizes billing and handling cost.
- 3) It provides an accurate and timely data base.

The STAR is aided by a computer with terminals at each of its branches. The package is scanned four times to insure accurate and reliable service. The four scanning points are listed below.

- 1) Origin City Station. The shipper calls the branch office in his city with a request for service. If he is a regular subscriber, he already has an addressograph data recorder. This allows the shipper to prepare the airbill (consignee address cards, return address, etc.) for FEC. The airbill contains four copies, one of which is used as a label for the package. The scanning is done when the carrier returns to his branch office in the shipper's city.
- 2) The second scan takes place in the Memphis Hub, where all packages are unloaded from the feeder aircraft and placed on a conveyor with a divert chute that utilizes zip codes. Once the divert chute has directed the package to the proper sender plane, it is scanned.
- 3) The package is scanned a third time when it reaches its destination city.
- 4) The fourth and last time the package is scanned is when the courier delivers the parcel to the consignee. The consignee's signature which indicated that he received the package is scanned when the courier returns to his branch office.

The air freight forwarders who buy lift from commercial airlines also have several advantages. The first advantage is that they usually employ indirect air carrier service, thus relying heavily on an aircraft owned and run by another organization. They know the exact flight schedule and route. The freight forwarders are free of the burden of making flight plans. Another advantage is that they avoid the high cost of operating an aircraft when their payload does not justify the flight.

There are several disadvantages for the air freight forwarders who employ commercial airlines to lift their cargo. First shipment carried by another carrier and across several modes makes tracing limited, if not impossible. In this event, the air freight forwarder is at the mercy of the passenger carrier with their scheduled and unscheduled delays. If a priority decision has to be made between passenger and cargo, the airline will usually go with 87% of its total income, the passengers.

2.4.5. Documentation

In order for the freight forwarding industry to achieve the objective, "of moving large air cargo from dock to dock in minimal time", improved technology in documentation procedures must parallel improvements in aircraft technology, intermodality, and ground support system. The air freight forwarding industry's biggest asset is time. It can't compete with other modes of transportation in terms of cost per shipment or volume per shipment. Time consumption is the airlines only superior quality. International trade by waterway between many nations is roughly 45 days, whereas by air it is less than one week (ref. 34).

In order for the air freight industry to reach its full potential, the delivery time of 6 days for international cargo must be reduced by one-half. The IATA reported the following graphic description for international cargo travel (ref. 34).

Function	Export Handling Agent	Export Custom	Export Carrier	Transfer Carrier	Import Carrier	Import Broker	Import Custom	Import Trucker
percent	15%	1%	15%	12%	15%	25%	2%	15%
days	1/2	1/4	1/2	1/2	1/2	1	1/2	1/2

The documentation procedure required for international air freight is to a large degree the cause of much of the delay.

Eric Rath reported that there are as many as 125 different types of documents in either regular or special use for international shipments (ref. 3). The 125 documents represents more than 100 separate forms. The forms include the bill of lading, through bill of lading, custom declaration, counselor documents, dock receipts, certificates of inspection and measurement, certificates and binders for insurance, banking documents, forwarders receipts, invoices, billing forms, and manifests. In addition to the forms in regular or special use, as many as 28 different governmental agencies may participate in a single export shipment.

New documentation procedures are needed that will cut down on the paper work and speed the cargo from the shippers' dock to the consignee's dock. Air Canada has made a step toward eliminating the greater portion of the paper work involved in the air cargo business (ref. 28). ACCESS (Air Canada Cargo Enquiring and Service System) is a data information system that prints out documentation paper as well as monitors the cargo at any point enroute. In 1976, the ACCESS System had 150 input terminals and 50 air waybill printers available for cargo business in 28 of Air Canada's offices, six in the United

States and four in Europe. The informational system is coded in the air waybill format. The computer is capable of performing the following operations with the coded data:

- 1) Work out the exact cargo costs
- 2) Note any instruction from the recipient (Example: Keep temperature above freezing)
- 3) Check the credit rating of the shipper
- 4) Print out waybill, if required
- 5) Pass on to the accounting department all data needed for billing
- 6) Prepare the weight and balance charts for the aircraft.

The system is sophisticated enough so that no papers have to accompany cargo inside of Canada and the number of papers accompanying international cargo has been drastically reduced. The waybill is printed and matched with the cargo at the destination in all of the airports within Canada.

Non-technical issues involved in documentation are Customs Clearance and apportionment of liability. The FMC, CAB, ICC, and IATA must solve these before international one-day dock to dock air freight will become a reality.

2.4.6. Single Waybill

To be effective, one carrier responsibility must include shipping under a single waybill. The single waybill covers inter-carrier agreements with all interline transportation agencies (air, rail, land, and sea) covering both tariffs and services for both domestic and international shipments. The advantages of shipping under a single document are: a) a reduction in billing and collections costs, b) the knowledge that the shipper or consignee knows exactly the total cost of the intermodal movement, c) the knowledge that one forwarder can monitor his shipment at any point and on any mode, and d) the knowledge that a single forwarder/carrier has liability for the shipment.

Shippers moving cargo using several modes of transportation where joint rates are not established often pay a higher cost than they would under a combination rate. In the case where an air freight forwarder tenders cargo from dock to dock where intermodal service is involved, only the forwarder initiates and processes the through bill of lading applicable to the trip (ref. 35). Since the down line carriers have lower terminal costs, their rate for service should be less; this would result in a lower cost to the shipper. Rates charged for door-to-door interline service by Emery are more economical than if modes for each link charge to make an individual profit. Emery Air Freight owns its own ground support service and buys air service. With this arrangement, each segment of the haul doesn't have to show a profit as long as the overall operation does.

If each mode of cargo transportation service would publish joint rates, one of the problems of shipping under a single waybill would be eliminated.

If intermodal shipment under a single waybill is to become a reality, recommendation 17 of Problems of Through Responsibility and Liability must be accepted:

"The ICC, the FMC, and the CAB in co-operation with the Department of Transportation should develop and publish one or more approved standard forms for inter-carrier agreements or apportionment of liability for intermodal shipment."(ref. 36)

The acceptance of this recommendation would solve a major problem preventing shipping intermodal cargo under a single waybill. In order for shipping under a single waybill to become a reality, domestic and foreign governmental agencies must co-operate with each other.

2.5 IMPACTS

Introduction

This section deals with the impacts the ground support system of an advanced air cargo system has on the environment around it. These impacts will be divided into three major areas: (1) Environmental, (2) Economic, and (3) Urbanization. The magnitude of any of these depends on several factors. The first factor is whether a new airport is being built or an existing airport is being expanded. A new airport would have far greater impacts than would an expansion program. The second factor which determines the magnitude of the impacts is the size of the airport. Again, a large hub-type airport has more significant impacts on the surrounding environ than a smaller spoke-type airport. In the discussion of the three areas of impacts, consideration will be given to both the new airport and the expanded airport. In addition, the significance of airport size will be discussed.

Even though this section deals with the impacts of the air cargo ground support system, there will be times when it will be difficult to separate this system from the passenger operation. Often it is the composite of these two airport operations that causes the impact.

2.5.1. Environmental Impacts

The construction of a new airport for air cargo or the expansion of an existing airport to handle increased air cargo will cause a number of environmental impacts. These impacts can be controlled to some extent by a good advanced planning program which gives high priority to the ecology of the surrounding environ. The environmental impacts may include the following:

- | | |
|----------------------------------|--|
| (a) noise | (f) sewage disposal demand |
| (b) air pollution | (g) soil erosion |
| (c) water pollution | (h) wildlife displacement |
| (d) drainage pattern alternation | (i) congestion of airport access roads |
| (e) water supply demand | (j) fuel consumption |

"The contribution of aircraft and airports to the deterioration of the natural environment are, at present, minor in comparison to the overall effects of urban and industrial development, the chief agents of environmental degradation."(ref. 37) However, as the air industry grows, so will its contribution to the degradation of the environment unless steps are taken to prevent it from happening.

What follows is a brief discussion of some of the environmental impacts mentioned above.

2.5.1.1. Noise

"Aircraft noise is presently the most urgent of all social-impact factors in civil aviation" (ref. 37) This opinion is one that is shared by many people, especially those living close to airports. The increase of air cargo traffic will certainly compound this problem in two ways. First, there will be an increased number of large, noisy airplanes and second, there will be the noise of the surface transportation carrying the cargo to and from the airport.

Noise is measured in CNR (Composite Noise Rating) or NEF (Noise Exposure Forecast). Noise levels below 30 NEF (100 CNR) are considered to be low enough so as not to produce complaints from those subjected to the noise. Noise between 30 and 40 NEF (100 and 115 CNR) will produce complaints and noise above 40 NEF (115 CNR) will probably initiate group action, such as a legal suit (ref. 37).

At present, there are a number of efforts being undertaken by the government and the aircraft industry to reduce noise around airports. These efforts are centered on three areas:

- 1) the source (aircraft)
- 2) the receiver (homeowner)
- 3) urban planning

There are several ways to reduce the noise from the source. First, the airplane engines can be designed to be less noisy. The L1011, a wide-body jet, is achieving noise levels below FAR Part 36 for takeoff, sideline, and approach (ref. 38). In addition to improved engine technology, airports can modify takeoff and landing procedures and times to further reduce noise impacts.

Once a homeowner has located near an airport, there is little that can be done by him, short of moving, to reduce noise levels. There have been attempts to sound proof the homes with limited success.

The final method of controlling noise is through the proper planning of urban development. This is such an important step that in order to receive federal money for new airports, the builder must show compliance with the Airport and Airway Development Act of 1970, as amended. This act requires

"appropriate action, including the adoption of zoning laws, have been or will be taken, to the extent reasonable, to restrict the use of land adjacent to or in the immediate vicinity of the airport to activities and purposes compatible with normal airport operations, including landing and takeoff of aircraft."

There are some land uses that are not sensitive to noise, such as farm land, manufacturing centers, warehouses, and other transportation modes. These could be located close to airports. On the other hand, homes, schools, churches, and hospitals are very sensitive to noise and should be located at some distance from the airport (ref. 39).

Proper urban planning is the answer to the noise impact for a new freight airport. However, for existing airports, it is too late to plan. The answer for the existing airport is the purchase of land surrounding the airport and have it rezoned for noise insensitive uses. This is an extremely expensive solution, with land surrounding some airports being worth \$300 000 or more per acre (ref. 40). On the other hand, law suits, lawyers, and other associated legal costs are also expensive.

Noise pollution is a problem shared by both passenger and freight operations. However, in promoting increased air freight operations, we must realize that the noise pollution problem is the single most important item constraining the growth of airports and airport operations.

2.5.1.2. Air, Water, and Land Impacts

In comparison with other sectors of the economy, airports and aircraft do not contribute much to the pollution of the air. However, the aircraft do produce combustion type emissions. There have been advances in engine design such as the turbine engine instead of the piston engine and other advances in combustor design (ref. 38). In addition, there is now the smokeless engine which eliminates visibility problems caused by the smoke generating engines. A large air freight operation also produces air pollution from the surface vehicles used to transport freight to and from the freight terminal. The impact of this pollution problem can be reduced by routing the airport access

roads through less densely populated areas. However, the control of air pollution is mainly a problem for new technologies.

"Although aircraft themselves do not contribute significantly to water pollution, terminal activities can exert significant effects on both surface and ground water through demands imposed on local water supplies, waste water discharge, or changes in drainage patterns." (ref. 37) In addition, the construction of terminals and runways destroys vegetation which can lead to soil erosion, further harming water supplies. It is estimated that, in order for air freight operations to derive the same revenue as passenger service now derives, it will require ten times as much terminal space (ref. 40). Thus air freight systems could use a significant amount of water as well as diminish the natural replenishment of water supplies unless careful resource planning takes place prior to construction.

2.5.1.3. Fuel Consumption

Currently the air transportation industry consumes approximately eight percent of the domestic fuel requirements (ref. 38). With the introduction of the widebody aircraft and improved engine efficiency, the trend of the fuel cost per tonne per kilometer is downward. However, much of this savings comes from the enormous payload capacity of the widebody airplane.

As petroleum based fuels become more expensive and scarce, technical advances will be required to support the aircraft and surface vehicles of the air freight industry. These advances may include the development of more efficient engines and/or the use of new fuels, such as hydrogen.

2.5.1.4. Airport Access Road Congestion

In general, airports are built convenient to major highways which provide good access, or the highways are promised. Approximately 90% of the ground access to airports, domestically, is by highway (ref. 37). Since air freight will require a significant amount of truck traffic to and from the airport, an additional strain will be placed on already overloaded road networks. For some of the large hub airports, ground access has become a major growth limiting factor (ref. 37, 40, 41). For these airports, land acquisition is also a problem which limits their ability to build additional highways.

There are three possible solutions to the access problem:

- 1) Use other modes to get freight and passengers to and from airports
- 2) Construct off-airport cargo facilities
- 3) Construct all cargo airports

The use of mass transit in the form of busses, subways, railroads, and helicopters between urban centers and the airport could reduce the congestion on the access network and reduce air pollution and fuel consumption as well.

The construction of off-airport freight terminals would reduce the truck traffic into and out of the airport. They also eliminate the problem of finding building sites on already land-scarce airports. These off-airport terminals would be used for consolidation of freight and could be shared with other freight transportation modes.

The final solution is an all cargo airport. This solution seems to be the least viable. In order to justify such an airport, there would have to be very large volumes of cargo such as might be found at a hub city. However, land is in general not available in these areas. Since belly cargo will still be carried on passenger flights, freight personnel, equipment, and buildings will be duplicated, which represents large sums of money and will necessarily increase the cost to ship by air. This would then reduce the air freight industry's ability to compete with the surface modes.

2.5.2. Economic Impacts

The economic impact of a new airport is much more dramatic than the expansion of an existing airport. In addition, the size and capabilities of the airport determine the economic impact, with the larger airports having greater impacts. Examples of economic impacts are:

- (a) employment
- (b) payroll
- (c) commercial and industrial development
- (d) increased land values

A hub-type airport can be a major employment center (ref. 41). For example, in 1970 Los Angeles International Airport employed 37 000 and was the second largest employer in the county (ref. 42). This represents direct employment such as airline, air traffic control, traffic, security, and maintenance personnel. In addition, airports create indirect jobs for people in freight forwarding, warehousing, and trucking as well as hotels, restaurants, construction, and car rental agencies. The total employment impact associated with an airport can be as many as 100 000 jobs (ref. 43).

If one were to assume an average annual wage of \$7 400 for each airport-created job and assuming 50 000 such jobs, an annual payroll of \$370 million would impact on the region. Further assuming an economic multiplier of 2.5 for the region, the airport would have a total regional economic impact of \$925 million (ref. 44). This impact would normally be considered very positive. However, the creation of jobs and income in one region can drain the labor force and financial base of another region. Thus one region could grow economically at the expense of another.

There is also some controversy as to the proper employment and monetary multipliers to apply to airports. Transportation in general has a derived demand rather than an intrinsic worth; in that respect, it is a non-basic economic activity in a city or region. It does not generate income from outside the area, but re-circulates that derived from the basic industries which do bring in dollars. Thus, it is part of another industry's multiplier.

Alternatively, the transshipment traffic at an airport does not derive from the region, hence could pass through other airports. The income from and employment related to it can be considered basic to the city. Thus, hub airports have a large segment of their activity which is basic, while feeder airports are totally non-basic in their orientation. Thus, a uniform multiple is misleading and many local facilities have only the very limited multipliers related to the goods and services purchased locally by their employees.

The magnitudes of the above mentioned numbers are for new airports. The expansion of an existing airport to handle more freight will not have such large impacts. However, it will necessitate the building of new terminals and possibly runways on the airport, and warehouses and other facilities off the airport. The construction and operation of these facilities will impact on both employment and payroll (ref. 45).

2.5.3. Urbanization Impact

Historically transportation modes have created population centers. First it was the ship creating seaports and then the train creating railroad centers (ref. 46). In much the same way, airports have a nucleating effect on land development (ref. 37). As was stated in the preceding section, the airport is an employer. Since people prefer being close to their work, housing is built close to the airport starting the population movement. At the same time, air related business and industry, such as airline companies, freight forwarders, car-hire agencies, etc. locate near the airport. This creates more jobs and more housing. Next comes industry which uses air for shipment of its product. These companies normally manufacture a high value product. There are also businesses which move in to serve the air passengers such as motels, hotels, convention centers, and taxi services. Finally there is the business and industry that locate near the airport because of the good highway network (ref. 47).

In all, there are large numbers of jobs created which in turn leads to the creation of housing for the employees and their families. With this population center must come such services as fire and police departments, public utilities, hospitals, shopping centers, schools, etc.

This type of urban development can lead to good or bad impacts. Without proper land use planning, the entire urbanization process can be a total disaster. The result of poor planning is homes, schools, hospitals, and other noise sensitive land users being close to runways. However, through long range planning, the land around the airport can be zoned to achieve proper land use.

Another factor should be included in the planning for an airport. Where are the people, business, and industry coming from? Often times they come from surrounding towns and communities. If the exodus is large, the impact on these towns and communities can be devastating. Such impacts are often overlooked by planners.

The urbanization impact discussed above is for a new airport. The magnitude of the impact is dependent on the size of the airport and its geographic location. The expansion of an airport would not have a large scale urbanization impact. It would, however, create new jobs and draw additional business and industry to the area.

2.5.4. Summary

The creation of ground support facilities for an expanded air freight industry will generate a number of impacts on the surrounding environ. The size of the facilities and their geographic location will determine the magnitude of these impacts. The impacts can be divided into three categories: (1) Environmental, (2) Economic, and (3) Urbanization. The environmental impacts discussed are detrimental to the environ, but the magnitude of these impacts can be minimized through advanced planning. Both the economic and urbanization impacts can be good or bad. Again, proper planning is needed in order to make them have a positive impact on the environment.

2.6 ISSUES AND CONCLUSIONS

Several issues need resolution before the ground support element of an ACIS will fill its prescribed role. Some of these can be resolved for the total system by high level policy decisions, the attendant legislation, and the appropriate administrative procedures. The correct alternative on others is related to operating costs, thus will vary with local conditions. Issues can be broadly associated with two categories: 1) airport and terminal design, and 2) institutional/legal.

The design issues include:

1. What modes require access to ACIS terminals?
2. What networks and technology should be used to provide access?
3. Should gate arrival terminals be instituted?
4. Should off-port assembly and distribution centers for small package cargo be built?
5. Should dedicated freightports be built?
6. Are "union" cargo terminals appropriate to ACIS?
7. Should intermodal container storage be open or covered, or some mix of these modes?
8. Can the ISO/ANSI marine type intermodal container be made to be compatible with ACIS?
9. What are the appropriate dimensions of containers for air transit?
10. Is the use of intermodal containers essential to significantly increasing the volume?
11. Does extensive use of containers imply cube- or weight-out problems for interface with aircraft?
12. What bay dimensions and loading capabilities should aircraft have to ease the surface/air interface?
13. What degree of automation should be used in cargo sorting, handling, and storage?
14. What sort of interface should be provided between the terminal and aircraft, e.g., fixed conveyor or mobile devices?

The institutional/legal issues include:

1. How can documentation on cargo movements be simplified?
2. What can be done to improve the processing of documents?
3. Is one carrier responsibility and a one carrier waybill necessary to ACIS?
4. How might marketing procedures be improved to help capture more cargo, particularly air eligible shipments which have here-to-fore traveled by other modes?

5. How can air freight forwarders be better incorporated into the movement of small package cargo?
6. Can night flights for air cargo be maintained given environmental concerns in many communities?
7. What local and national land use planning requirements will be necessary to insure that airports with airfreight operations enhance the economic conditions locally while not detracting from intracity circulation, service delivery, and residential functions?

The evidence assembled in this section points towards certain rational courses of action with regard to these issues. First, it was shown that even through the 1990 period, trucking will be the major mode requiring access; COFC or possibly TRAILS rail access will also be useful at "air bridge" ports. The access technology need not be different from existing roadbuilding, but roads should be separated from passenger related traffic as soon as possible on entering the port authority property. Secondly, no alternative which abrogates economies of scale or divides belly freight in passenger planes from freighter cargo should be entertained. Thus, design alternatives like gate arrivals, off-site satellite terminals, and all freight airports, including military strips, are not considered feasible for ACIS. Union terminals, in that they enhance scale economies, are preferred. Third, it was evident that the ACIS should be designed around the 6.1m ISO/ANSI box in its various heights. This is appropriate to the lots of large package air eligible commodities likely to be transported in the projection period. Both the high tare weight of the containers and the higher density of this new type of traffic imply a reversal of the current loading problem in air cargo, i.e., in 1990 the planes will weight out before they cube out. All new craft can be expected to load the 6.1m boxes, hence should have nose or tail bays which can accomodate them. Fourth, it is evident that fixed docks are more efficient for moving containerized freight than mobile equipment. Such automation as supports these docks is beneficial. Alternatively, the degree to which automation is effective in small package handling is open to question. Many operations may not require it.

Finally, many of the service deficiencies of current operations could be eliminated by single-carrier responsibility, the single waybill that supports it, and computerization of the waybill and such additional documents as accompany given shipments. This would expedite transfer of cargos, allow direct contacts with the responsible transportation company by the customer, and facilitate accurate tracing of shipments through the system. Night service is also needed to attract an expanding business. Any aircraft or land use planning efforts which support night operation are beneficial.

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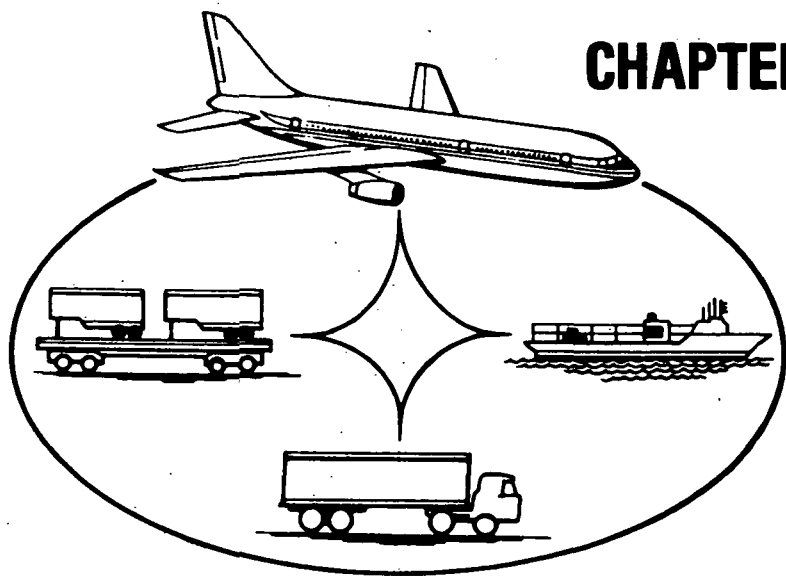
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CHAPTER 3



REGULATIONS AND REGULATORY AGENCIES

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REGULATIONS AND REGULATORY AGENCIES

Introduction

1978 has been a year of rapid change in the air freight industry. The extensive deregulation passed by Congress in late 1977 was beginning to be felt in the marketplace, although some statutory provisions would not phase in until after this report went to press, and the CAB was actively considering regulatory revisions that would become effective even later.

In this context, an attempt to "predict" the regulatory climate as far ahead as the 1990-2015 period would be doomed to failure. At the same time, a strictly short-term approach would not provide the guidance which is the purpose of this report. Finally, the extent and complexity of federal regulation of both air carriers and other forms of common carriers made a complete survey of the details of regulatory practices unfeasible.

Accordingly, this chapter is directed to the following principal goals: First, a brief history of aviation regulation and mention of the principal agencies regulating aviation and some of those regulating the carriers with which air carriers must interact. Second, a discussion of the present economic deregulation, some of its implications for the industry, and prospects for the near future. Third, a discussion of the prospects for intermodal transportation of freight and the various legal and regulatory impediments. Fourth, a discussion of the problems presented to the industry by aircraft noise regulation and some possible approaches to these problems. The intent has been to provide both concrete guidance for the near term and an image of the sort of regulatory structure needed to optimize the contribution of air freight to the nation's economy in the 1990's and later.

3.1 REGULATORY AGENCIES

Government regulation of transportation in the U.S. reflects the evolution of the various modes of transportation. Each mode developed separately and in different time periods. Regulation of the different modes occurred for one or more of the following reasons: (1) Users of a transportation mode complained of unfair pricing practices by the owners of the mode. (2) Carriers within an industry complained of unstable market conditions and predatory competition by other carriers. (3) Promotion of stable and efficient transportation was considered to be in the national interest.

The airline industry, although a private enterprise, has seldom been very far removed from government regulatory influence. The Post Office Department began air mail transportation in 1918 but relinquished this to commercial aviation by 1927 in an effort to encourage the development of the commercial sector. Subsequent legislation continued this trend culminating in the 1938 Civil Aeronautics Act which established as government policy the promotion, protection, and development of the American airline industry. But after four decades of a highly regulated system the opposing tendency of less regulation has arisen. The 1977 all-cargo air service deregulation enactment had this basic intent as does pending Congressional legislation to deregulate passenger air service.

3.1.1. The Civil Aeronautics Board (CAB)

The condition of the airline industry in 1938 was quite unlike it is today. The official rationale for the 1938 Act was to promote and protect the industry from "unrestrained competition" which was felt to be detrimental to the government and the industry (ref 1). The Act created a single regulatory agency, the Civil Aeronautics Authority, now known as the Civil Aeronautics Board, charged with the responsibility of economic regulation and control of the air transportation industry.

By regulating entry and exit in the industry, as well as routes and rates of interstate air travel, the CAB both promoted and protected the existing companies. Competition among the major carriers was effectively limited to the scheduling of service and on-board amenities on fixed routes and with fixed rates.

In 1958 the U.S. Congress passed the second major piece of legislation affecting the airline industry - the Federal Aviation Act. This amended and replaced the 1938 Act and, although not altering the economic regulatory authority of the CAB, created a separate entity - the Federal Aviation Agency (FAA) - with authority to "control all aspects of airspace management." (ref 2) This includes pilot certification, traffic rules and all safety matters.

Since 1958 there have been several amendments to the Act but no major revisions until 1977. After a series of hearings focusing on airline deregulation, the Congress, unable to agree on a comprehensive proposal, reached a compromise agreement on cargo deregulation alone and passed that as a part of an insurance risks amendment to the 1958 Federal Aviation Act. The deregulation segment of the amendment (Public Law 95-163) is hereafter referred to as the 1977 air cargo deregulation enactment.

While "ruinous" economic competition led to the 1938 Act and concern for airline safety resulted in the 1958 Act, a strong undercurrent supporting government deregulation appears to have been the moving force behind the 1977 enactment and pending passenger deregulation proposals.

Some of the major airlines have opposed deregulation, arguing that it would be detrimental to the public in general and the industry in particular. Despite this opposition there has been sufficient support in Congress, the Executive branch, and various public and private interest groups, as well as from some of the airline companies, such as United and Pan American, to ensure passage of the cargo deregulation enactment and probably ensure future passage of a passenger deregulation bill as well.

In addition to being more efficient and more economical, supporters of deregulation argue that it would be a move away from big government and toward a free-enterprise system. Thus deregulation is in the interest of both the general public and the airline industry. Opponents of deregulation, such as Eastern Airlines, argue that a move toward deregulation would be detrimental to the industry since it would result in "an overcompetitive situation" and could lead to "stagnation and nationalization." (ref 3. p.809) But in 1977 naysayers were in the minority and the first major piece of deregulatory legislation became law.

It is too early to accurately foresee how extensively the enactment will alter the cargo industry. However, with the CAB's subsequent further liberalization of the law by utilizing its authority to exempt all cargo carriers from specific requirements of the 1958 Act, the cargo side of the airline industry has the potential to be radically altered.

A major change resulting from the 1977 legislation is that the policy of the CAB now includes the provision to encourage the "development of an expedited all-cargo air service, provided by private enterprise" that would be responsive to the needs of shippers, American commerce and national defense. The service should also rely "upon competitive market forces to determine the extent, variety, quality and price of such services." This was the first time that the Congress explicitly mandated the CAB to concern itself with air-cargo service.

Other significant alternations to the 1958 Act include ordering the Board to issue newly created "all-cargo air service" certificates to applicants who are "fit, willing and able" to provide service. No longer does the applicant have to demonstrate the necessity of such service. The 1977 law also withdrew the Board's power to control routes and substantially reduced

its control over rates. In addition, the CAB has itself contributed to the deregulation movement by exempting the all-cargo carriers from certain regulatory requirements, such as reporting and accounting procedures. A final important change is that, although air carriers will be exempted from restrictions placed on consolidations, mergers, and interlocking relationships, they will no longer be immune from antitrust laws, as had been the case since the 1938 Act.

At the present time, the Board is considering several proposed rules which would further deregulate the air cargo industry and promote free market interplay.

3.1.2. International Aspects of Regulations

Although most of this study concentrates on the domestic aspect of air cargo service, the international market for such service is substantial and has experienced significant growth in recent years. From 1965-1975 combination carriers providing international air cargo service doubled their freight volume while all-cargo carriers freight volume increased 600% in the same period (ref 4, pp. 125-126). In 1975 world freight moved by air consisted of 22.3 billion RTKs (15.3 billion RTMs) with 23% of that occurring in the United States alone and nearly 60% involving shipments either within, into, or from the United States (ref 5). Yet the regulatory aspects of international air freight are quite different from domestic air freight.

There is no authoritative international agency regulating air transportation and the international system is much more complex than a national system and subject to sharp and sudden perturbations. In order to deal with this phenomenon the International Air Transport Association (IATA) was created in 1945. This followed the 1944 American sponsored Chicago Convention called "to formulate universal international air transport policy for international travel and commerce." (ref 6) Not surprisingly, the participants, representing over 50 nations, were unable to agree on a universal policy and retained the practice of negotiating routes on a bilateral basis.

A primary function of IATA is to set rates and fares on international routes, subject to approval by member nations. This has provided the airline companies with a certain degree of stability and uniformity. Yet recent reports of dissatisfaction with IATA has led the CAB to propose reconsidering American membership, raising the possibility of American withdrawal from the organization (ref 7). This inclination is the result of both dissatisfaction with the rate-fixing mechanism of IATA as well as the deregulatory mood within the CAB.

Two important issues of concern to international airlines are route locations and frequency of flights. Such arrangements have been made by bilateral agreements many of which have been modeled on the 1946 Bermuda Agreement signed by the United States and Great Britain. In recent years, nations have placed increased restrictions on flight frequencies and authority to transport cargo or passengers from or through one of the signatories to another foreign country. Such restrictions clearly hinder the development of an efficient and integrated transportation system.

One potential problem faced by American international airline companies is that many foreign airlines are government owned or subsidized, thus placing American private enterprise at a disadvantage when negotiating such agreements. According to William T. Seawell, Chairman Pan American Airways:

U.S. flag carriers face increasing competition from foreign carriers, old ones better managed and more strongly financed than they have been in the past, new ones spring up for reasons of national interest and all supported with a new nationalistic aggressiveness by their parent governments. (ref 3, p.453).

Yet this has hardly been the case. Foreign airlines have at least as great a desire for routes to the United States as American airlines have an interest in routes to any single foreign nation. In addition, the enormous influence of the United States in international commerce has resulted in American airlines faring quite well in most bilateral arrangements. The United States Department of Transportation recently announced a proposal that outlined a much more assertive American position in negotiating international air transport agreements. It stated that one aspect of its negotiating policy would be to "agressively pursue our interests in expanded air transportation and reduced prices." (ref 8) This policy coupled with the CAB's inclination to withdraw support from IATA makes it appear highly unlikely that the American airline industry will, in any way, be at a disadvantage in negotiating international service agreements.

3.1.3. Related Regulatory Agencies - The ICC and FMC

The other agencies regulating common carriage transportation, the Interstate Commerce Commission (ICC) and the Federal Maritime Commission (FMC), impact air cargo service through controls over their carriers who provide carriage prior or subsequent to transportation by air. Of the two, the ICC regulatory impact is substantial. Under the Interstate Commerce Act, the ICC has jurisdiction over motor carriers, railroads, (inland) water carriers, and freight fowarders. However, the Act exempts from ICC regulation motor carriage of property which is "incidental" to air carriage. As would be expected, the CAB and ICC have had a historical and ongoing dispute over the boundary between their respective jurisdiction, focusing on the meaning of the word "incidental" in the exemption clause. What resulted was CAB control over pick-up and delivery services within a 25 mile radius of the airport or city limits served by the motor carrier. All motor carriage moving outside of this 25 mile barrier is regulated by the ICC with a few exceptions. This so-called 25 mile "rule of thumb" continues to be a substantial barrier to the expansion of air cargo service to new outlying markets. However, on recommendation from several parties, the ICC in 1977 proposed an extension of the limit out to 100 miles, the fate of which is still under consideration at the present time.

Regulatory authority over common carriers operating United States and foreign flag vessels in transoceanic and coastal commerce is vested in the Federal Maritime Commission. There has been insignificant CAB-FMC jurisdictional friction in the past as the air and sea modes operated virtually

independent of each other. But with the advent of air/sea service using containerization in recent years, the FMC will naturally influence air cargo service through its authority over the sea connection.

3.1.4. Institutional Constraints and the CAB

In the theory, the CAB, as an independent government agency, merely carries out its regulatory functions as mandated by the United States Congress. But this mandate is seldom clear, and is in some instances contradictory. According to the amended 1958 Federal Aviation Act the policy of the Board shall be to:

1. encourage the development of an air transportation system suited to the needs of American defense, commerce and the postal service;
2. regulate air transportation so as to foster safety and sound economic conditions;
3. promote adequate, economical and efficient service;
4. have competition "to the extent necessary to assure sound development" of such a system;
5. encourage the development of "an expedited all-cargo air service system, provided by private enterprise."

To develop a safe, efficient, competitive system that provides adequate passenger, cargo, and mail service and meets the needs of national defense is clearly difficult if not impossible. In addition, there is substantial disagreement regarding the meaning of such terms as adequate, competitive, and efficient.

But upon close examination it is evident that the activities of the CAB, like the other regulatory agencies, are sharply circumscribed by institutional and political forces. Members of the Board are nominated by the President for a fixed six-year term subject to Congressional approval. The President also appoints the Board Chairman for a one-year term, thus assuring that the Chairman, if not also the Board, would be supportive of relevant policies of the Executive branch. Other considerations limiting the actions of the Board are: the interests and policies of the Department of Transportation may overlap with those of the CAB; the President must approve any regulatory changes pertaining to foreign air travel; the power of the Board to issue a particular order under the Federal Aviation Act is subject to judicial review in Federal Court.

Institutional tendencies also limit the Board's independence as well as its effectiveness. Delays in arriving at decisions, overresponsiveness to the interests of the regulated industries, failure to coordinate policies and activities with other agencies and departments are some of the major limiting factors.

Studies seem to indicate that the CAB is afflicted by the same influences and tendencies of most bureaucratic agencies: it tends to assume that its immediate interests and the interests of its clientele are synonymous with the public interest; it is subject to the political influences and pressures of special interest groups, particularly those it regulates; its policies are narrow and inconsistent since they are usually formulated on a worst case basis (ref 9,10,11). These factors combined with the broad array of policy objectives mandated by Congress and the inclination to tailor its policies to the concerns of the Executive branch often result in complex and even contradictory policies. The current support for deregulation could disappear or be significantly altered following the election of a new Administration and/or the appointment of new board members or chairmen. It is unlikely that these broader tendencies will be significantly altered in the near future or that the Board will radically change its policies; current deregulation trends notwithstanding.

3.2 CAB Requirements

3.2.1 Recent Changes Resulting from Deregulation

The regulatory situation in the air cargo industry is now in a state of rapid change. Therefore, this section will discuss some of the specific aspects of the changes resulting from the 1977 law. The deregulation enactment added a new section to the Federal Aviation Act, Section 418, creating a new certification process specifically for domestic all-cargo service. It provided that all certified carriers, supplementals, and air taxis which had furnished all-cargo services before the enactment would be "grandfathered," thus automatically receiving the new operating certificate upon application. Any citizen wishing to become a new entrant to the all-cargo market is required to wait for one year after the November 9, 1977 enactment date before applying for section 418 operating authority. By eliminating the showing of "public convenience and necessity" required of applicants under section 401 of the Act, and specifying that an applicant must be granted a 418 certificate unless found not "fit, willing, and able," virtual free entry was established for new entrant hopefuls.

Since section 418 was hastily enacted, its language is often unclear, resulting in problems of interpretation. In several respects, the enactment poses more questions than it answers. Subsection (b) (1) (B) states that unless an applicant is not fit, willing, and able, "the Board shall issue a certificate . . . authorizing the whole or any part of the all-cargo air service covered by the application." What do the words "whole or any part" mean in terms of the Board's authority? Since the definition of "all-cargo air service" includes the carriage of property, mail or both, does application to carry only one of these constitute a request for partial service, which the Board must grant? The service is defined the same whether either or both types of cargo are carried; thus, the definition itself offers no division. In addition, this "whole or any part" provision was omitted from the grandfather certificate requirements. It is possible that Congress intended that the Board have some discretion as to the type of service a new entrant would be allowed to perform. Under this latter interpretation, it appears that the Board has a potential entry control beyond the "fit, willing, and able" criterion.

A similar problem exists where the section permits the Board to revoke a certificate for a carrier's failure to provide "minimum service." Presently, no one seems to know what is meant by "minimum service." The magnitude or form of service that must be maintained is unknown and may be determined in the future. The phrase remains, however, as a potential for Board control.

Because air cargo deregulation was split from its parent bill and hurriedly passed, the CAB was caught somewhat by surprise. The agency was not really prepared to implement deregulation on such short notice. However, the Board was philosophically committed to free market competition; thus, it issued interim regulations granting carriers a series of exemptions from Board control.

The Board's present policy is to promote free market competition in air cargo, thus permitting the deregulation experiment to proceed with minimal regulatory interference. The success or failure of deregulation in the air cargo industry will determine whether the Board reinstates controls in the future.

Congress has mandated that free market competition be the cornerstone of the all-cargo industry. However, a couple of provisions in the enactment demonstrate a Congressional intent to preserve a degree of regulation. The law created new tariff filing and new tariff review requirements under sections 403 and 1002 respectively, designed especially for the carriage of property as distinguished from passenger regulations. If Congress has intended total deregulation, they would have omitted such requirements altogether, instead of creating new, special ones. The intent of Congress was for the Board to effectively preserve its limited right to review cargo tariffs under section 1002. This intent should be measured, however, in terms of the present air cargo market. Congress may have intended for the Board to actively maintain its review authority during the transition to free market competition, after which the Board, at its discretion, could grant exemptions from review where the market was protecting fair trade. In large measure, it will be for the Board to define the Congressional intent, but ultimately the Courts may have to decide the issue.

Potentially the most significant aspect of the new section 418 is the Congressional grant of authority to the Board allowing it to exempt all-cargo carriers from any section of the Federal Aviation Act which the Board by rule or regulation deems appropriate. The Board has already issued exemptions from several sections of the Act in recent months. It is conceivable under this provision for the Board to completely exempt all-cargo carriers from the Act. By the same token, the Board may revoke such exemptions by subsequent rules or regulations. In order for the CAB to define its new role as a regulatory agency, a balance must be struck between its Congressional mandate to deregulate on one hand, and an awareness by Congress and others of the need for some continuing regulation. It is the establishment of this equilibrium defining the Board's role which will determine the future of the system.

3.2.1.1 Tariffs

Tariffs are written statements of the rates, rules and practices under effect in or proposed for an air carrier's or an air freight forwarder's service. Tariffs must be filed with the Board and constitute public notice of their contents. By statute, air carriers must file any changes in their tariffs 60 days before the effective date of the change. Air freight forwarders must file only 45 days in advance. The rates, rules, and practices filed in a tariff may be reviewed by the Board under section 1002 of the Act, which gives the Board a limited authority to alter them when found to be in violation of that section.

The Board has decided not to exempt all-cargo carriers from filing tariffs, at least for the near future (ref. 12). In its decision, the Board noted that filing was necessary to monitor the economics of the industry during the transition to free market competition. The Board mentioned, however, that maintaining the tariff filing requirement was arguably inconsistent with effective competitive ratemaking, and hinted at dropping the requirement after free entry takes effect in Fall 1978.

If free market forces are to effectively govern the industry, it is necessary to reduce as much as possible artificial economic conditions created by remaining requisite regulation. Yet, the system will be best served if the tariff filing requirement is retained in an altered form. Filing is needed to enable the Board to monitor the industry so as to effectively fulfill the Board's duty under section 1002 to guard against prohibited tariff practices. At the same time, advance filing should be eliminated to erase the economic imbalance created by the lag time between filing and effective date. By requiring filing of tariffs on the date of effect, rates will immediately and accurately reflect the market, but simultaneously giving the Board a sufficient "picture" of the industry to intelligently enforce against prohibited tariff practices.

3.2.1.2 Routes

Section 418 of the Act prohibits the Board from restricting the points to be served by domestic all-cargo carriers. These carriers may freely choose the points they will serve as well as the routing between those points. The geographic scope of section 418 operating authority is air carriage in commerce among the 50 states, the District of Columbia, Puerto Rico, and the Virgin Islands. Also included are flights between points in the same state except within Alaska and Hawaii, which pass outside the airspace of that state, and flights between points within any U.S. possession or territory (excluding Puerto Rico and the Virgin Islands), or the District of Columbia.

The routing of cargo carried in the bellies of combination aircraft operating under section 401 certification remains regulated as a consequence of continuing passenger regulation. Since passenger routes are regulated, the cargo in the bellies of passenger aircraft is subordinated to the passenger routing. Of course, air transportation of some cargo may include both all-cargo and belly movement, and that part which in all-cargo carries is unrestricted.

Presently, passenger aircraft may not deviate from their authorized passenger routes in order to provide cargo service to other points. This restriction limits the potential flow of belly cargo. Deregulation in the passenger field may give the airlines more routing flexibility which would result in greater compatibility between the cargo and passenger services of combination carriage. However, even with passenger deregulation, the carriage of belly cargo will remain subordinated to the particular needs and scheduling sensitivities of passenger carriage.

3.2.1.3. Rates

The 1977 deregulation enactment substantially reduced the authority of the CAB to regulate the rates charged for the carriage of property by aircraft. Under section 418, the Board may not impose conditions or limitations on "all-cargo air service" certificates restricting rates. This action marks the first time Congress has specified such regulatory relief for a class of carriers. Heretofore, Congress had delegated all such decisions to the Board under the Act. Now all-cargo carriers have Congressional permission to freely set their rates.

Another significant change with potentially greater impact on deregulation was a reduction in the Board's authority to review air cargo rates under section 1002. Congress amended the section to create a new and separate standard for the review of cargo rates as opposed to review of passenger rates. The amendment eliminated the power of the Board to find rates in violation of the Act because they are "unjust or unreasonable." In addition, the Board may no longer suspend rates under review. The Board was granted the more limited authority to "alter" rates which are found to be unjustly discriminatory, unduly prejudicial or predatory. This new review standard applies to the carriage of property in interstate commerce whether as an all-cargo service or as belly cargo.

The importance of the new review standard is that it has eliminated the "unjust or unreasonable" standard which has been the foundation of cargo rate review since the Board was established. The terms "unjust or unreasonable," because they are capable of broad meaning, have given the Board great latitude in examining rates. These terms have been the standard against which all rates were measured, and provided the core of the seven year long Domestic Air Freight Rate Investigation (DAFRI) which was the most extensive review of air cargo ratemaking ever undertaken. The Board recently decided to vacate nearly all of its orders under DAFRI because they were made obsolete by the elimination of the old standard (ref. 13). Only a few orders were left in effect, because they did not rely on the "unjust or unreasonable" rationale.

The meaning of the new limited standard is yet unclear in practice. The words "unjustly discriminatory, or unduly preferential, or unduly prejudicial" were included in the old standard. The amendment has added the "predatory" criterion. While the first three terms constituted part of the old standard, they were usually defined in terms of rate levels set by the "unjust or unreasonable" rationale. In actuality, the Board often invoked neither of these three terms because the broader "unjust or unreasonable" standard could cover many situations. The Board in vacating DAFRI stated that whatever these terms meant under the old standard is not necessarily applicable today, and that once "reasonable" practices might now "present questions of unjust discrimination or undue preference or prejudice" (ref. 13, p. 5).

The Board has currently adopted a policy stating that issues involving the new standard must be determined in light of the facts and circumstances of each case. Generally, though, discrimination is defined as charging different rates for a like and contemporaneous service in the transportation of like traffic under substantially similar circumstances and conditions. Undue preference and prejudice are similar to discrimination, but involve services to different points which are merely related and not alike. Predation is essentially pricing below cost with the intent of driving out competition.

It should be said that the Board currently intends to apply these standards sparingly in order to promote free market flexibility. The Board has stated that these standards will only be defined in terms of rates established by market forces. If the Board acts too soon in enforcement of these standards, their interference in the market would influence the very ratemaking process from which the standards are to be defined. Time is needed to allow the air

cargo market to develop into a mature state before the standards are too strictly imposed. Only time will allow the standards to effectively reflect the market conditions which will define the standards in practice.

While the Board no longer has the power to suspend or prescribe rates, it may "alter" a rate after finding the rate in violation of one of the standards discussed above. What exactly is meant by the Board's power to "alter" rates is unknown at present. In light of the standards of unjust discrimination, undue preference or prejudice, which basically define inequitable practices, it is reasonable to conclude that the Board has the power to alter the violative rate by making it equate to the rates to which it was compared. It might also allow the Board to average rates if market forces show that the alteration of the violative rate will change the comparative rate. In other words, the Board may alter individual rates, establish equal treatment, but it cannot prescribe what the overall rate level will be. As for predation, the Board will have more control and discretion because it must first determine what the costs are before deciding if rates are below costs, and then decide if there is an anti-competitive intent involved. It would then have to set what it considered a competitive rate. In any event, these are merely suggested interpretations of the Act from a careful reading thereof and are presented as a guideline for understanding. The Board will have to act to give a more definite meaning, and the interpretation by the Board will, in all likelihood, be contested in court.

3.2.1.4. Rules

Rules, as opposed to rates, are the statutory common carrier obligations of an air carrier. Such obligations include the requirement to be liable for loss or damage and to generally carry the goods of anyone upon a reasonable request. Rules are filed in tariffs in the same manner as rates. They are also subject to the same basic review as rates under the amended section 1002. The comments above on the Board's current authority to review rates should generally apply to rules as well.

Of the various rules filed, those establishing the liability of air carriers for loss or damage of goods carried are of great significance. The liability obligation is a traditionally important duty of the common carrier. Under common law, with a few exceptions, common carriers are absolute insurers of the goods they carry. They are held liable up to the value of the goods carried.

Statutory laws, including the Federal Aviation Act, have replaced common law in establishing liability requirements for common carriers. Either expressly by statute or by regulations promulgated under statutory authority, common carrier liability has been limited and/or expanded in numerous ways. Before 1977 deregulation, the Board limited air cargo liability to \$9.07 per pound. At the same time air carrier liability was expanded by the Board to include special or consequential damage liability not required under common law.

The Board may no longer prescribe liability rules under the amended section 1002, and its power to alter rules may be exercised only in limited circumstances. The courts on the other hand, with one exception, have held that they have no authority to review rule or rate tariffs lawfully filed with

the CAB. These court decisions rest on the theory of "primary jurisdiction" which states that the courts have no power to review regulatory matters where Congress has delegated such authority to a regulatory agency. As a result of this regulatory and judicial impotence, air carriers are free to set their own liability rules with virtual immunity from review. Several air cargo carriers have recently reduced their liability limit to \$.50 per pound and have exempted themselves from special or consequential damages. The Board allowed these changes pending a determination of its post-deregulation authority, but hinted that its authority is probably very limited.

The adverse effect of these changes on shippers is obvious. Air carriers cannot be allowed to all but absolve themselves from liability. Recommendations on this matter are proposed later in a discussion of bills of lading.

The duty of an air carrier to furnish air transportation upon a reasonable request is found in section 404 of the Act. Usually rules filed in this regard are attempts by carriers to exempt themselves from this duty with respect to certain requests for service. A notable example of this process is the long-standing attempt by air carriers to exclude themselves from having to carry live animals as small packages. Only recently, the Board decided that section 418 certified carriers must continue to provide this service because it is a "reasonable request" (ref. 13 pp. 7-9). However, this decision was made pending a final determination by the Board at a later date of the overall common carrier duties of section 418 certified carriers. If a long-term unified transportation policy is developed, it is possible that special cargo such as live animals and hazardous substances might be carried only by particular modes or over particular routes. Pending such policy, however, it would be unwise to allow the air carriers to substantially eliminate this service.

One final note on the duties of air common carriers. Section 404 requires that air carriers provide service with reasonable rules, while section 1002 limits the Board's authority to alter rules. Unless the Board should exempt 418 certified carriers from section 404, that section provides the Board a method to require at least a minimum level of carrier responsibility even where it cannot alter the rules under section 1002.

3.2.1.5 Current Trends

It is still too early to reach solid conclusions as to the effect of deregulation on the air cargo industry. Most commentators agree that no major trends will appear until after free entry takes effect in Fall 1978. However, current trends do give some hint of industry response to free market competition.

Service has expanded generally. All-cargo carriers have added service to new points which they could not acquire approval to serve before deregulation. Carriers have expanded their fleets in number and size of aircraft, enabling them to offer more service to more points. The result was a notable increase in domestic ton-miles for the first quarter of 1978. This rapid increase in service reflects an adjustment of the all-cargo industry to market demand.

Ratemaking also appears to have been affected by market conditions. There has been a general increase in commodity rates contrary to the expectations of many proponents of deregulation. However, the rise can be attributed to existing carriers taking advantage of the current situation in which there are only a limited number of competitors in the market. After November 1978, the entry of new competitors should drive rates downward. Assembly and distribution charges and rates for specialized services, like the carriage of live animals, have substantially increased, an apparent reflection of the additional and special costs of these services in light of the limited demand for them.

Yet there have been rate reductions as well. Several carriers have introduced discounts for space-available daylight service or guaranteed regular shipments over a minimum weight in bulk loads or in containers. The overall rate reduction for daylight service is consistent with the low market demand for daylight cargo service. Accompanying rate differentials allowing greater discounts for larger bulk or container shipments is also consistent with market pricing since cost per unit decreases as shipment size increases. Moreover, carriers have engaged in discount-offer competition, each attempting to give the best discount.

Besides recent changes in liability rules, carriers have altered the unrouted traffic rules. Carriers no longer, as previously required, charge the lowest line-haul rate between two points, regardless of the actual routing. Instead, carriers are now determining the routing when not specified by the shipper, and are assessing freight charges on the actual routing of the shipment. The result is that charges more closely reflect costs. With the entry of new carriers, routing under this scheme should become more rational, as carriers compete to offer the shortest routing.

3.2.2 Impacts on Management

With the present rapid changes in the regulatory situation, it is difficult to project even two or three years into the future, and impossible to make projections into the 1990-2015 period with any confidence. Nevertheless, it may be in order to suggest some possible ways in which management may react to deregulation over time, and to mention some possible structural changes for the industry.

3.2.2.1 Rates and Load Factors

An air carrier serving a given route and seeking to maximize profit may control several variables. The most important are price and capacity. Capacity includes not only the size of aircraft but also the number (frequency) and scheduling of flights. Insofar as frequency and scheduling are the most important determinants of shipping delay (elapsed time from when a package is ready to leave the shipper until its arrival at the consignee's loading dock), capacity is the most useful measurable proxy for "quality of service." To the potential customer for air freight, time has a value; he will use air cargo services to an extent determined by both the cost of the service to him and the quality (primarily speed) of the service he receives.

In the past carriers had extremely limited freedom (if any) to set rates; thus, adjustments in capacity offered were a principal management tool. This phenomenon has been closely studied in the case of passenger traffic (ref. 14, 15). These passenger market studies found that under CAB regulation, carriers tried to adjust their profit levels in a given market by adjusting capacity offered. If they enjoyed high load factors, they would tend to expand capacity, increasing quality of service (decreasing the average delay experienced by passengers) so as to attract more passengers. This increased traffic, but it also tended to decrease the average load factor, and thus increase cost per passenger carried. Each carrier, of course, sought to maximize total profit. Similarly, in a market with low load factors, the carrier would try to decrease capacity, decreasing traffic but increasing the load factor and thus decreasing cost-per-passenger. All this was done in the context of fixed price per passenger.

The studies argued that the prices actually fixed were not maximally efficient. In view of the costs of passenger time and availability of competing modes, passenger load factors should be greater in long-distance than in short-distance markets, and greater in dense markets than in sparse markets. In the early 1970's, the opposite was true in practice. Thus they urged that prices be cut in the longer and denser markets. If this did not adequately increase demand, it would lead to pressure on carriers to decrease supply, but in either case, it would increase load factors.

Shortly after these studies were published, the CAB did in fact move to increase load factors in these markets, but in a very different fashion. Under the banner of fuel conservation, it encouraged competing carriers to agree to limit capacity in selected markets without cutting prices.

In 1977-78, while passenger rates were not deregulated by statute, the CAB allowed carriers considerable flexibility in reducing rates (via promotional fares), and the carriers were quick to take advantage of this. This would seem to demonstrate a serious interest on the part of the carriers in (a) determining price elasticity of demand more accurately than was possible under strict regulation, and (b) determining feasibility of carrying out in practice several price separations long advocated by the theoretical economists, e.g., charging more for certainty of scheduling (a reserved seat as opposed to a reduced standby fare), preferred hours (reduced off-hour and weekend fares), and schedule flexibility (reduced rates for 7-day or 30-day advance reservations).

The attempt to separate passenger markets by special fare programs is consistent with past evidence in the cargo category. The small-package services of the major airlines is an attempt to price separately for a distinct market segment, as are the lower ("daylight") rates for cargo carried in passenger aircraft bellies. The success of Federal Express shows that an entire network can operate on a single one of these markets in some cases.

Typical load factors for cargo in 1976 differed drastically between all-cargo and combination service. All-cargo planes had an average 53 per cent load factor, while cargo space in passenger plane bellies was typically on 26 per cent utilized. Passenger load factors increased fairly rapidly in 1977 and early 1978 as the CAB permitted carriers to introduce the special fare programs; this is evidence that carrier managements agreed with the economists that increasingly differentiated fares and higher load factors were desirable.

3.2.2.2 Future Rates and Load Factors

Therefore, it seems reasonable to suppose that the carriers will continue the process of differentiating markets, introducing special fares to fill available capacity, and regarding fares as being a competitive tool, at least as important as capacity offered. This may be expected to lead to increasingly segmented markets; to a fare taper (with distance) more extreme than before deregulation; and to higher costs for users requiring special services (e.g., shippers of live animals and hazardous materials). It is probable that even if the United States returns before 1990 to a more regulated environment, some of these changes will persist: that is, that the fare structure will be somewhat closer to a competitive-optimum rate structure than it was before 1977.

As demand for all-cargo service grows, it will become increasingly feasible for the air carriers to assign larger aircraft or multiple aircraft to particular markets, thus giving them more leeway in capacity offered than is now possible except in the very largest markets. These changes, as well as fare adjustments, will continue to drive load factors up. On the other hand, load factors in scheduled service tend to be limited since there must be reserve capacity for busy days or seasons. It seems most likely that load factors in common carrier service in the 1990's will be about 65 per cent on the average, somewhat lower in sparse markets and short-range markets (where frequent service is necessary to compete with trucks) and somewhat higher in dense markets and long-range markets. Charter operators and special market segment operators (e.g., Federal Express) who are more able to adjust levels of service to actual demand, on a single-flight or day-to-day basis, should also enjoy somewhat higher load factors than average.

A problem is presented by certain relatively small and high-cost operations where active competition is unlikely. For instance, it appears that the CAB is presently unwilling to see live-animal carriage dropped. Can it allow prices to rise without eventually causing the service to essentially cease due to lack of demand at the high prices? What about regular service between a small outlying city and the appropriate hub? Where there is a single carrier in such a market, will fear of competition keep the price at a reasonable level, or might the market be so small that this is unlikely? It appears probable that a mechanism will be found to continue regulation in these areas: for instance, by asserting that in some circumstances carrying live animals or hazardous materials is necessary to providing a "minimum level" of service, or by declaring excessively high rates to be "predatory." Competition and the increased efficiency of higher load factors will in all probability keep the overall level of air freight rates from rising faster than inflation. It may be reasonable to conjecture (based on the reasoning in the Domestic Air Freight Rates Investigation, even though as a formal precedent it is obsolete) that rates in smaller markets will be kept in about 130 per cent of the rate in a similar competitive market.

In an air cargo industry with unregulated rates, certain problems arise that are not present in a regulated market. On the one hand, rates for a given

commodity on a given route may in fact become fixed by competition: several carriers charging essentially identical rates with a change in rate by one typically met by the others. There will then be various arguments either that this violates the anti-trust laws, or that it should be formalized and exempted from the antitrust laws (for instance, in order to "stabilize" the industry, or to make fare changes more predictable for shippers, or to increase load factors and reduce fuel consumption). Alternatively, there may be a large variety of rates and terms of shipment offered by various carriers (a situation not unlike that prevailing with cut-rate air passenger fares in mid-1978). The next few sections discuss some possible changes in the market structure in these circumstances.

3.2.2.3 Rate Bureaus

Several of the transportation modes in the U.S. engage in collective rate-making practices through organizations known as rate bureaus. Rate bureaus are not permitted in the U.S. domestic airline industry; however, IATA functions as a rate bureau. Given a significant increase in air cargo transportation under an advanced air cargo system, the establishment of rate bureaus in the air transportation industry might be considered. The following paragraphs discuss the history and functions of rate bureaus in surface transportation and the implications for rate bureaus in air cargo transportation.

History and Functions of Rate Bureaus

Rate bureaus are nonprofit, carrier-maintained organizations that are legally permitted to initiate joint carrier pricing action (ref. 4, p. 171). In rate bureaus, rate proposals may be filed by shippers, consignees, bureau members, other carriers or by the bureau's standing rate committee. After a proposal has been filed, a public hearing may be held at which all interested parties have the opportunity to make their views known. In addition to their collective rate-making function, rate bureaus also perform the following functions: disseminate information on regulatory changes, publish rates, and provide carriers a forum for discussing problems of mutual concern. Rate bureaus are found in the railroad, the trucking, and the domestic water carrier industries, and membership in a particular bureau is restricted to carriers of a single mode.

In the past, rate bureaus were generally regarded by carriers and shippers as desirable mechanisms for maintaining stability and fairness in rate-making practices. However, as part of the current movement toward transportation deregulation in the U.S., rate bureaus have increasingly come under attack by shippers (ref. 16). The main complaint of many shippers is that rate bureaus provide too little consultation with shippers in rate-making procedures. In addition, some shippers, particularly smaller ones, would prefer to have more individual bargaining rights with carriers. In fact, the effect of a provision in the Railroad Revitalization and Regulatory Reform Act of 1973 will allow individual bargaining between shippers and some railroads.

Implications for Rate Bureaus in the Air Transportation Industry

Rate bureaus might be considered in air cargo transportation on two levels: (1) domestic air cargo transportation, and (2) international air cargo transportation.

In the domestic case, rate bureaus were established during the early days of rail and motor carrier transportation and it is tempting to suggest that rate bureaus might also be established in a developing air cargo industry. However, given the airline deregulation movement and the wishes of many shippers for more individual bargaining rights with carriers, it is unlikely that rate bureaus will be established. Only if deregulation should result in very unfavorable conditions for shippers and carriers over an extended period of time would the establishment of rate bureaus become a serious possibility.

Internationally, IATA is a global rate bureau which represents more than 100 airlines. IATA divides the world into traffic conferences, and airlines operating within or between these conferences periodically meet and agree on rates. The rates are then filed with the governments involved for approval. Conference meetings are not open to the public or users of airline services. IATA has not been particularly effective in its rate-making functions, but it does serve as a forum for the international airline industry and has provided a certain degree of stability in the industry. Thus, it is likely that IATA will continue its past functions, although the relationship of its members may vary from time to time (see the discussion of the changing role of U.S. airlines in IATA in section 3.1.2).

3.2.2.4 The Travel Agent Function

There are two types of middlemen in today's airline industry. In the cargo sector, the air freight forwarder serves as a middleman between shipper and air carrier. On the passenger side, there is the travel agent who makes arrangements for the passenger with an air carrier. The two functions are basically different in nature. The forwarder accepts packages from the customer-shipper, and then as a shipper purchases air carriage for the shipment, making a profit by charging one rate to the customer and then paying a lower rate to the air carrier (for instance, by obtaining a quantity rate or using charter services). Travel agents, on the other hand, sell air transportation to passengers, but in an agent capacity to the air carrier. The agents are remunerated by a commission on tickets sold. This section explores the possibility of the travel agent function applied to air cargo.

The growth of air passenger traffic has been considerably assisted by the relationship between the airlines and travel agents. The travel agent provides the public with services including consultations about available rates, routes, and schedules as well as the actual writing of tickets, performing functions which if they had to be performed directly by the airlines would require substantial additional personnel costs. The agent attracts the public not only by offering services that could be offered by an air carrier in the usual course of business, but by offering other services, by his ability to appear neutral as between carriers, and by promoting demand for service not supplied

by one single carrier (e.g., trips which require that different portions be flown on different carriers).

The creation of travel agents, or commission sales agents, for the transportation of cargo might have extremely beneficial results. One reason that the growth of air cargo has not kept pace with some expectations is probably the lack of effective selling. While salesmen employed by air carriers and air freight forwarders have been able to call on the largest potential customers in cities where there is significant traffic, they have not been able to call on relatively small customers, or even on mid-size customers located away from carrier/forwarder offices or whose transportation needs will require a larger mix of suppliers. The commission agent able to represent a large variety of companies will have substantial incentive to make such calls. Further, since a great many shipping decisions are in practice made by blue-collar employees--shipping clerks or shipping managers who are not motivated to devote time to comparative studies of competing modes or carriers--such salesmen might find a ready audience.

There is one other strong argument for the creation of a freight equivalent of travel agents. If such commission agents could function, and if arrangements could be made for them to represent not only various air carriers (and possibly forwarders) but also companies providing other modes of transportation, they could be a significant force in establishing an intermodal transportation industry. They could provide a customer with a single source of information about several ways of getting a shipment to its destination, and even provide the waybill(s) for a trip involving several modes and carriers.

It should be noted that many in the industry argue that the role of travel agents is dependent not only on the existence of regulations permitting air carriers to pay commissions to non-employees who sell tickets, but also on a specific antitrust exemption which permits the air carriers and agents to agree on a uniform fixed commission system. It has been argued that in the absence of the uniform system, one carrier could try to induce agents to direct passengers to it by raising commission rates, leading to a competitive spiral and eventual increase in fares. While it seems very probably that the CAB will eventually permit the paying of commissions, it seems highly unlikely in the present climate that the antitrust exemption will be forthcoming.

The argument that an antitrust exemption and fixed uniform commissions are necessary is not wholly convincing. While much of the stock brokerage industry developed on a fixed commission rate system, competitive commissions have been allowed more recently (of course, here the commission is paid by the retail customer). The real estate brokerage business has also functioned without an antitrust exemption. Finally, there is some experience with competition even in the presently-constituted air passenger travel agent business; an agent is paid a percentage commission which is reduced if the agent finds a way to make travel cheaper for the passenger (e.g., a lower fare); the pressure on the agent to do a good job for the retail customer is thus not in terms of immediate reward but in terms of return business. Presumably, travel agents do try to seek low fares for their customers when available, rather than trying to maximize their commission per transaction.

Even accepting the desirability of the freight travel agent function, many questions remain. Should this function be performed by an air freight forwarder? It has been argued that there is a significant conflict of interest between the forwarding and travel agent functions. (Some of the issues were touched on in a speech made by Chairman Kahn of the CAB to the Air Freight Forwarders of America on July 2, 1978). A forwarder thrives by selling his own service which uses those of others, while a travel agent exists by selling the services of others for whom he is an agent. The tension between being, in effect, a shipper in the former case and a carrier's agent in the latter creates an essential conflict of interest. The best solution to this problem may be separate the two functions, with competition between forwarders and travel agents. Present forwarders might even choose to switch over to the travel agent function, instead of continuing as forwarders. This question may well be settled by the CAB during 1978, at least for the near future.

How effectively could or would the agent serve as a package tracer? Obviously it would be beneficial to give the shipper or consignee a single contact point with problems about damage, delay in shipment, etc.; this is not a traditional travel agent function, but there might be considerable benefit to the carriers as well as the shipper in having at least the more routine inquiries processed through an agent, who would be more likely to know who to call and what to ask than a relatively small individual shipper (especially on an intermodal shipment).

3.3 Intermodal Relationships

3.3.1 The Current Regulatory Situation

Intermodal transportation involves the transfer of a shipment from one mode to another as it moves from origin to destination. Although intermodal transportation is not a new concept, technology is presently available which greatly facilitates intermodal transportation and results in greater transportation efficiency. Intermodal transportation will be a necessary part of an air cargo system, and the technical aspects of intermodal operations in the ACIS are discussed in other sections of this report. There exists, however, in the areas of transportation management and government policy toward transportation, barriers which prevent the most efficient intermodal transportation that is technically possible.

Intermodal cargo transportation utilizing air carriage as the primary or secondary mode is an established fact. A series of regulatory compromises and relaxations between the CAB on one hand, and the ICC or FMC on the other, have promoted the growth of intermodal service involving air carriage. While regulation remains a barrier in certain respects, the range of intermodal service possibilities is broad, and many exist in practice. This section outlines the present situation in air cargo intermodality, the purpose being to lay a foundation for discussion of needed changes.

3.3.1.1 Air Carrier Service

Air carriers provide intermodal service utilizing motor carriage under a variety of arrangements. For many years, air carriers have provided pick-up and delivery service by motor carriers within a limited area surrounding the airport served. Some air carriers operate this service themselves while others provide it through their jointly wholly owned subsidiary, Air Cargo, Inc. These pick-up and delivery services must be performed within the "air terminal area," defined generally as a 25-mile radius around the airport served by the carrier. Such motor carriage being "incidental" to air carriage is exempt from ICC regulation, and comes under CAB authority as a service "in connection" with air carriage.

Another air/motor arrangement is "motor-substitute-for-air" carriage. Under this arrangement, an air carrier substitutes truck transportation for existing transportation by aircraft as a connecting service between two points which it serves. The motor carriage stands in the place of an actual airline flight between the airports at these points. The air carrier assumes full one carrier responsibility for the movement which is performed by an underlying ICC regulation motor carrier. All air carriers must obtain permission from CAB for this service, and tariffs must be filed as with any air service route. This includes all-cargo carriers operating under section 418 since there is currently a question as to what degree that section deregulated ground carriage by all-cargo carriers. The major difficulty with the new section is that because the Board cannot restrict the points to be served, all-cargo carriers, unless regulated, could substitute motor for air carriage at numerous new points and, therefore, get heavily involved in trucking operations. Such

action would run contrary to the original purpose of this service which was to relieve air carriers from the expense of flying aircraft for mere connecting service. The Board is presently reviewing its authority in this matter.

Another air/motor service in widespread use is a contract arrangement between an air carrier and an ICC regulated motor carrier for connecting service. The ICC motor carrier provides line-haul and/or pick-up and delivery services beyond the 25 mile radius of the air terminal area. A variety of through service arrangements are possible, but the trend is toward one carrier responsibility utilizing a single bill of lading. It should be noted that similar arrangements are possible between air carriers and ICC rail or water carriers, although air/rail and air/water services are practically non-existent.

Air carriers have offered an intermodal service in conjunction with FMC regulated ocean-going carriers. An example of this is the Sea Tiger service managed by Flying Tiger. The primary reason for this air/sea service is to connect ocean cargo commerce between the Orient and Europe via air transportation across the continental United States. By using air cargo service between western and eastern ports in the United States, the long ocean voyage through the Panama Canal or around the tip of South America is eliminated, saving both time and money. Air/sea service has also been expanded to include shipments originating at or destined to points within the United States. The 1977 deregulation enactment accompanied by subsequent CAB action has given all-cargo carriers a great deal of latitude in such arrangements. However, FMC regulation over its carriers remains strong. Moreover, much of oceanic shipping is governed directly by laws of Congress so that the FMC has little discretion even when it wishes to institute change. The upshot is that ocean-going carriers do not have the same flexibility to reach compromise arrangements as do air carriers.

3.3.1.2 Air Freight Forwarders

Forwarding is not really a mode, but a service which uses modes. Air freight forwarders are users of the air mode, although some of them also offer pick-up and delivery service by truck incidental to the use of the air model. Forwarders may conduct their own pick-up and delivery service within a 25-mile radius of either the airport or the limits of the city served by the airport, depending on the base of operation they use. Forwarders wishing to provide pick-up and delivery service beyond this 25-mile radius must utilize an ICC regulated carrier for that service. The Federal Aviation Act prohibits air freight forwarders from establishing joint rates (including liability) with ICC carriers, to separate carrier responsibility is required for such service. However, the ICC recently granted some air freight forwarders a way around this barrier to one carrier responsibility beyond the 25-mile limit. These forwarders were licensed by the ICC as "subsequent or prior" carriers to carriage by aircraft with a limitation that the carriage must be performed by an underlying ICC motor carrier. This arrangement avoids the prohibition of the Act because the forwarder is then both a CAB and ICC carrier, but contracts with the underlying ICC carrier only in its ICC role.

Air freight forwarders may use ICC carriers as a substitute for long-haul carriage by aircraft, but only where an emergency exists beyond the control of the air carrier used by the forwarder. The motor-for-air substitution must be at the forwarder's expense, and the shipment will travel under an air bill of lading.

Under the Long-Haul Motor/Railroad Carrier Air Freight Forwarder Authority Case, the CAB has granted ICC motor and rail carriers virtual free entry into the air freight forwarding market (ref. 17). The only significant stipulation was that the CAB would only grant such authority for ten-year periods, with renewal possible. This action should facilitate intermodal coordination between air, motor, and rail modes.

3.3.1.3 Bill of Lading

The bill of lading is the receipt for possession and the contract of carriage of goods in shipment. It is a document necessary to all common carriage. Existing intermodal through services use either single or multiple bills of lading. The deciding factor as to the documentation procedure used in a given intermodal through service is the liability contract arrangement within that service. Liability may be stated in terms of one carrier responsibility, joint carrier responsibility, or multiple-but-separate carrier responsibility. Under the first of these liability arrangements, one carrier contracts with the shipper to be responsible for the entire movement which utilizes at least one connecting carrier acting as an agent for the principle carrier. Joint liability occurs when two or more carriers contract together with the shipper such that each of them is responsible for the entire through movement. Both of these liability arrangements permit the use of a single bill of lading because a single liability is common to the entire through movement. However, where multiple carriers cannot establish such a single liability, separate bills of lading are required to establish each carrier's responsibility for its part of the entire movement. In this situation multiple bills of lading are necessary, multiplying documentation and often resulting in confusion and delay. Regulatory changes are needed to facilitate the use of the single bill of lading as a simplified documentation procedure.

The major regulatory barrier is the existence of differing liability requirements among the transportation agencies for the carriage of the same type of goods. Differing liability among carriers in an intermodal through movement necessitates multiple bills of lading. The authority of the agencies to regulate liability is enumerated in various acts, with great variations of authority existing between each agency. CAB all-cargo carriers now have a great degree of flexibility in setting their liability, but ICC and FMC carriers are still strictly regulated in this regard. The difference in liability valuation by granting a reduction in carriage rate. These limitations vary with the value of the commodity involved. FMC ocean carriers in international commerce between U.S. and foreign points, or vice versa, may limit their liability valuation under COGSA (ref. 18), but not below \$500 per unit, and only after meeting certain conditions. Problems have resulted as to exactly what constitutes a "unit" in any given ocean shipment. A "unit" may be based on the commodity or how that commodity is packaged.

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In addition to the valuation of liability, the cause of liability is significant. While carriers cannot exempt themselves from liability for their own negligence, they may exempt themselves from other causes beyond their control. However, the hazards and perils peculiar to each mode often differ, creating differences in the scope of their liability, as formulated by acts of Congress and regulatory or judicial decisions.

Closely related to this jungle of liability standards are differing insurance requirements among the agencies. The insurance requirements are usually based on assumed liability and, therefore, present as many problems as the liability differences.

Another problem related to liability results from differing commodity codes among the agencies. Since liability is usually calculated in terms of these commodity codes, if a particular commodity is classified differently by each agency, the liability will usually differ as well.

Up to now, the single bill of lading for intermodal through service using carriers regulated by different agencies has only been possible through unilateral and multilateral agency actions permitting a common liability. Either one agency will exempt its carrier from that agency's requirement, or two agencies will take compatible actions so that a common liability can be achieved among carriers. This is a cumbersome and inefficient process which needs replacement.

Congressional action is necessary to clear the way for increased use of the single bill of lading in intermodal through service. The present regulatory agencies can compromise only so far on liability before reaching their statutory limit of authority in this regard. As suggested later in this report, a single intermodal regulatory agency is needed. In creating this new agency, Congress should consolidate and rework present liability statutes and regulations to meet the concerns of shippers and carriers alike. This radical action will involve changing traditional concepts of liability which are deeply rooted. Congress should pass legislation letting out the basic requirements for common liability including a common unit for valuation of liability, a common list of exemptions from liability and common insurance requirements. The legislation should delegate to the new agency the authority to set the minimum value of liability based on the common unit. If this authority is delegated, the minimum value can be adjusted to meet particular needs, unlike a fixed limit set by Congress. At the same time, this delegation will put the minimum value decision out of the judicial branch, where the enforcement of minimum levels under the common law had been ineffective in the past. However, the courts will maintain an active role in enforcing carrier and agency compliance with the basic concepts of the new act.

While reasons exist for liability differentials between modes, much of the present division is a result of separate development of the modes with each attempting to establish the best liability for its own mode. It is time for a compromise that will allow the use of a single bill of lading in intermodal through service and thereby benefit the entire carrier industry.

3.3.2 Common Ownership

Intermodal common ownership is the ownership of two or more modes of common carriage by the same legal entity. There are three basic types of intermodal common ownership. One type is the multi-modal corporation in which the modes are brought together in a single corporate entity operating under one management. Multi-modal corporations can occur through the merger or consolidation of corporations operating different modes, or when a single-modal corporation initiates operations in another mode. A second type of intermodal common ownership exists when a corporation operating one mode purchases controlling interest in the stock of a corporation operating another mode. This arrangement is commonly called a "parent-subsidiary" relationship. The final type of intermodal common ownership exists when a single person acquires a controlling interest in the stock of different corporations operating different modes. The corporations remain separate legal entities, but they share a common owner.

Although not of itself constituting intermodal common ownership, a significant method of intermodal common control exists where one person holds directorships in two corporations operating different modes. Such an "interlocking relationship" also occurs when a controlling stockholder of a corporation operating one mode (or his representative) holds a directorship in a corporation operating another mode.

3.3.2.1 Anti-trust

A major issue of concern in examining common ownership is whether or not it may violate anti-trust laws. In the United States, Anti-trust control is exercised under two separate schemes. One method utilizes the so-called "anti-trust laws" which are embodied primarily in the Sherman and Clayton Acts, and are enforced by the Justice Department and the courts. The other method grants anti-trust control into the regulatory agencies. Congress decided that these agencies were better equipped and qualified than the courts to rule on anti-trust matters concerning the regulated industries. Thus, by act of Congress, the CAB, ICC, and FMC have been delegated anti-trust authority over their respective carriers.

Under the Federal Aviation Act, the CAB has the duty to approve or disapprove mergers, consolidations, and acquisitions of control (section 408), interlocking relationships (section 409), and pooling or other agreements (section 412) by utilizing anti-trust concepts. The decisions of the Board under those sections expressly immunize the carriers involved from the anti-trust laws. This authority of the CAB not only extends to arrangements between its own carriers, but also to arrangements between CAB carriers and ICC or FMC regulated carriers. The ICC holds similar authority over its carriers, but unlike the CAB, its authority only extends to arrangements between the carriers it regulates. This same qualification applies to FMC anti-trust regulation. The result of these gaps in ICC and FMC anti-trust control is that any ICC-FMC carrier arrangements are subject to judicial review under the anti-trust laws.

3.3.2.2 All-cargo Carriers

Acting under its exemption power in section 418, the CAB recently exempted all-cargo carriers from the anti-trust sections (408, 409, 412) of the Act. The Board specified that its order was not an order under the anti-trust immunity section, 414. Thus, all-cargo carriers are now subject to judicial review under the anti-trust laws. Although the anti-trust laws will have to be tested, in theory these carriers are now free to establish common ownership or control arrangements with air freight forwarders, other air carriers, and carriers of the other modes without CAB approval. They may purchase other carriers and, thus, acquire the operating authority of those carriers. As the ICC and FMC can only control common arrangements made among their own carriers, respectively, all-cargo carriers do not need the approval of those agencies to establish common ownership or control with the carriers regulated by those agencies.

3.3.2.3 Air Freight Forwarders

The CAB has proposed an extensive deregulation measure with respect to air freight forwarders. Air freight forwarders will be relieved from CAB anti-trust review but made subject to the anti-trust laws the same as all-cargo carriers. Thus air freight forwarders will have the same freedom to establish common ownership and control arrangements with air carriers or other common carriers. A specific provision will allow any air carrier to acquire an air freight forwarder free from CAB anti-trust review. Should these proposed rules not be approved air freight forwarders may still apply to become all-cargo carriers under section 418 and be entitled to all of the exemptions allowed such carriers.

3.3.2.4 ICC and FMC Carriers as Air Carriers

Prior to the 1977 deregulation enactment, ICC and FMC carriers were effectively, though not expressly, prohibited from owning air carriers. Motivated by fears that "takeover" by other modes would destroy the airline industry, the CAB has never found under section 408 that an ICC or FMC carrier could "use aircraft to public advantage in its operations and (would) not restrain competition." Thus, with the exception of a few railroads who owned air carriers prior to the 1938 Act and were "grandfathered" thereunder, the Board has not allowed carriers of other modes to own air carriers. Moreover, the CAB could prevent these carriers from starting their own air operations because it could find under section 401 that such service was not of "public convenience and necessity."

Now, because of section 418, as long as an ICC or FMC common carrier is "fit, willing, and able," it may become an all-cargo carrier. Having achieved all-cargo air service authority, these carriers may enter service either by creating their own new air operations or by acquiring an existing air carrier under the exemptions from CAB anti-trust review.

3.3.2.5 Barriers

Despite the removal of most CAB regulatory barriers to intermodal common ownership, the anti-trust laws and the regulations of other agencies still

create substantial barriers. Now that common ownership or control arrangements involving all-cargo carriers are subject to the anti-trust laws, the courts have the power of review over such arrangements. It is impossible to predict with any certainty what type of arrangements the courts will permit as judicial review under the anti-trust laws turns on the facts and circumstances of each case. Whether judicial anti-trust review will be more or less strict than the previous CAB review is unknown. Yet, the courts should take a more objective approach than has the CAB because they do not share the Board's pro-air carrier bias.

Even where the anti-trust laws, if tested in court, would permit common ownership or control, the legal costs involved in researching the anti-trust implications are often so high as to deter the owner of a mode from embarking on such ventures. It is the fear of anti-trust and not the anti-trust laws themselves which form the barrier.

Legal costs also come into play in an air carriers decision to seek ICC authority to start a trucking service. Approval for trucking routes is granted on a point-by-point, route-by-route, and case-by-case basis, causing the legal costs to run high. Air carriers are, thus, indirectly deterred by ICC regulation from seeking trucking authority.

Many other barriers to intermodal common ownership or control exist such as separate traditions within each mode, lack of imagination, the overall cost of such ventures. Yet it might be argued that the complexities and uncertainties inherent in regulations pose more barriers than the substance of the regulations themselves.

3.3.3 Managerial and Policy Implications

Transportation regulations were usually established in response to problems within a particular mode. Each mode became subject to a regulatory mechanism which was responsible only for that mode and which was intended to resolve specific problems. This ad hoc approach to transportation regulation, though perhaps appropriate at times, has resulted in each mode's development into a separate system within the total transportation system. The different modes are often in competition with each other. Intermodel competition has often been regarded as desirable on the grounds that more competition (inter- as well as intra-modal) will ultimately benefit the consumer. Criticisms of the current transportation arrangement are levied at the unnecessary duplication of service resulting from intermodal competition, the lack of coordination among the different modes, and the promotion and protection of each mode by its regulators, which, the critics argue, hinders the attainment of an efficient, integrated system.

From a regulatory standpoint there are various policy alternatives to accomplish efficient intermodal transportation: (1) voluntary agreements among carriers in different modes to provide intermodal transfers, (2) government enforcement of intermodal coordination, and (3) development of regulations which would permit companies to operate in several modes (integrated or multi-modal transportation companies). Each of these alternatives is discussed in the following sections.

3.3.3.1 Voluntary Cooperation Among Carriers in Different Modes

Under current national transportation policies voluntary cooperation is the way in which much of the intermodal transportation takes place. These agreements are subject to the approval of the regulatory agencies concerned. There are limitations to the success of intermodal transportation through voluntary cooperation of different modes. If one accepts the economic assumption that each firm will maximize profits, it follows that when firms in different modes must interact in transporting a shipment, each carrier will handle the shipment such that the shipment produces the maximum benefit to his own firm (e.g., will try to keep the shipment on his segment of the journey as long as it is profitable for him to do so). This may not be in the best interest of the shipper. Other problems in voluntary cooperation arise from different managerial practices among firms and differences in regulations of the various modes. Management practices such as pricing policies and accounting procedures, as well as incompatible physical facilities at interfaces, may cause impediments to smooth intermodal transfers. In the negotiation of mergers which involve firms within the same industry, the integration of the management structures of the merging firms poses many problems and often determines the success or failure of the merger. Thus, attempting to coordinate these factors among independent firms of different modes is even more difficult. Government regulations which focus attention on separate modes of transportation also complicate intermodal transportation.

The form of intermodal transportation which is most important in an air cargo transport system is the air/truck combination. It is also in the interaction between these two modes that examples of inefficiencies resulting from regulatory policies can be seen. Inefficiencies have resulted from the different freight rate structures for air freight and motor carrier freight as had been established by the CAB and ICC, respectively. (Under the newly enacted air cargo deregulation legislation the CAB has far less authority in regulating rates). Shippers and forwarders have argued that the 25-mile rule prevents the forwarder from offering the best possible service to shippers located outside the zone (ref. 19, p. 67).

Progress has been made recently in facilitating voluntary agreements among carriers of different modes. This is largely due to the recognition of the efficiency of properly executed intermodal transportation and its importance in an energy conscious society. The precedent has been set for a single waybill in air cargo (see section 3.3.1.3). The CAB recently granted Trans World Airlines permission to truck air freight between Milwaukee and Chicago at air freight rates (ref. 20). This decision opens up issues concerning the role of motor trucks or other surface carriers in air cargo service. Investigations are underway which examine the possibility of expanding the 25-mile exempt zone. Changes in all of these areas will lead to improvements in intermodal transportation.

Through cooperation of the regulatory agencies involved, more efficient intermodal transportation through voluntary agreement among modes can be encouraged. It appears this is the current trend. It must be noted that even

with fewer regulatory barriers to voluntary cooperation, the problems associated with coordinating policies of different firms still exist.

3.3.3.2 Government Enforcement of Intermodal Coordination

Current trends in government policies indicate that regulatory agencies are working toward facilitation of voluntary coordination among carriers of different modes. Even under an extensive program of voluntary agreements some problems would still exist in achieving intermodal transportation. The different modes would still remain competitors and in pursuing the best interests of their firms might not necessarily act in the best interest of the shippers. Problems would also result from different management policies of the firms involved. A way of resolving these problems would be to implement government regulations which would establish standards for uniform technical characteristics and financial procedures. But changes in the governmental regulatory structure would be required.

Although the functions of the Department of Transportation include the formulation of a national transportation policy and the encouragement of transportation coordination, the department exercises no regulatory powers over the various transportation modes except in safety matters (ref. 20 p. 275). The Secretary of Transportation cannot dictate policy to the various regulatory agencies which are responsible for carrying out the provisions and policies of the regulatory statutes which govern them. An important step in reorganizing the regulatory structure would be the formulation of a national transportation policy, emphasizing a coordinated transportation system. It would still be necessary to have agencies which would provide some regulatory control over certain areas of transportation. However, the agencies would be divisions of a larger organization, would be subservient to the overall policy of transportation coordination, and would be divided functionally rather than according to mode. Regulation of safety matters in the different modes would be one definite area of regulation. Other possibilities might include agencies which monitor intermodal transfers and joint rates.

The advantage of such an organization is that there would be an overall policy which would enhance coordination of the nation's transportation modes. However, the organization would be subject to the problems inherent in any bureaucracy. The extent to which the large agency would become involved in regulation is subject to the arguments for and against government regulation. Rigid regulations for some of the above-mentioned areas are not in line with the current movement toward deregulation in transportation. The regulatory agencies comprising the divisions of the larger organization should serve the function of monitoring, rather than regulating, economic aspects such as rates and routes, providing guidelines for intermodal transfer, and enforcing safety standards in the various modes.

Yet, regardless of whether a voluntary or government managed approach urged greater intermodality, the major hinderance would still be an institutional one, i.e., altering those established practices and procedures of the different elements of the industry. The problem that arises is not as much how to develop a common set of rates and documentation procedures or deciding what regulations would have to be altered to achieve that end, but how

the system could be made to accept it. The shippers and handlers would have to be convinced that their existing procedures needed to be altered. This could be accomplished by either government fiat or voluntarily.

A direct government mandate requiring a standardized method of handling freight documentation would seem the most effective method of implementing such a change but this is unlikely in the United States. The fractionalized nature of the industry as well as the limited nature of government involvement makes it unlikely that, other than for an extreme emergency or crisis situation, the government would try to impose such a change. It would require a coordinated effort of the Congress, the Executive and the regulatory agencies, along with the tacit support of the industry.

It is more probable that a gradual and voluntary movement under the direction and guidance of the regulatory agencies would be the most realistic method of implementation. But even at that it would still require the coordination of the ICC, CAB, FMC and the Department of Transportation to first develop the procedures that would result in a single way bill and standardized documentation. Even though such a change would probably be the single most significant contribution to the eventual development of an intermodal transportation system, since it is not very urgent or critical there is not going to be a great deal of interest in it. Most shippers, handlers, and regulatory officials are concerned with more urgent and pressing needs and have little time or interest in changes that would have long term payoffs. The inherent tendency of organizations is to alter procedures only when it is required or when it is viewed as directly beneficial. Although standardization of procedures would undoubtedly benefit the freight industry as a whole it would be difficult to measure the immediate and direct benefits to any single mode of transportation and even more difficult to measure any benefits to any single element in a mode. Therefore, such institutional restraints are a very real barrier to developing an intermodal freight service.

3.3.3.3 Multi-modal Transportation Companies

The two previous sections discussed means of attaining transportation coordination through active government participation. There are those who advocate the formation of multi-modal transportation companies as a way of facilitating intermodal transportation without involving the government to such a great extent in business operations. A multi-modal transportation company is a single corporate entity which combines several forms of for-hire transportation. The terms, "intermodal ownership," "integrated transportation companies," and "vertical integration," are synonymous with multi-modal companies.

Federal transportation policies tend to restrict the formation of multi-modal companies. As usual, there are strong arguments for and against multi-modal companies. Several references present potential advantages and disadvantages of common ownership. The following arguments, pro and con, are taken from Suelflow and Hille (ref. 22) and Lieb (ref. 23).

Arguments in Favor of intermodal ownership

1. According to those who favor common ownership the greatest advantage of multi-modal transportation companies would result from the ideas of a single corporate entity. With one organization in charge of the administration of several modes, intermodal transfer would be facilitated, a single pricing policy could be implemented, and the best possible combination of services utilizing different modes could be offered to the shipper. Competition could still be assured, since there would be many multi-modal companies offering such services.

2. Common ownership of several modes would strengthen the nation's common carrier system by making maximum use of each mode. Inequalities which now exist among modes, including user charges and subsidies, would be removed.

3. The shipper would find it advantageous to have his transportation needs filled by one company. The appropriate combination of modes could readily be provided, and the same carrier would also be responsible for any loss and damage claims.

4. Long-run economies of scale resulting from common ownership would result in cost economics. lower and more stable rates, and more expeditious handling of LCL shipments.

Arguments Against Intermodal Ownership

1. Some of the arguments opposing multi-modal companies are based on the concern that railroads would eventually dominate the transportation system. According to these arguments railroads would be most interested in promoting rail service due to their heavy sunk investment and would phase other modes out of existence.

2. Destructive competition between the transport companies and the small independents of various modes would result in elimination of the independents.

3. The management of multi-modal companies would find it difficult to operate all modes because of differences in economic structure. The consequence would be that each mode would be organized as a separate operating entity and there would be little opportunity to spread overhead costs.

4. Multi-modal ownership would stifle the development of the newer forms of transportation.

5. While advocates of common ownership argue that common ownership will improve competition, lower rates, and improve service, opponents of common ownership maintain that multi-modal companies would result in a transportation monopoly, higher rates, and a deterioration of service.

Most of the arguments against common ownership reflect the concern over concentration of power by one mode. The most severe restrictions of common ownership are placed on the railroads and originated during a time when railroads dominated other modes of transportation. While common ownership among the nonrail modes is not specifically restricted by law, policy interpretation

by the regulatory agencies involved have nevertheless limited the degree to which common ownership may occur. A restriction commonly applied to intermodal ownership operation is that services of one of the modes involved must be auxiliary or supplemental (as opposed to parallel) to the operations of the other modes. This has been the interpretation of the CAB in cases involving control of air carriers by surface carriers. While the intent of the restriction has been to prevent predatory competition by a single mode, the effect has been to limit the use of the most appropriate mode for a particular service.

Present day conditions in the transportation industry outdate many of the restrictions against intermodal ownership, particularly in the restrictions directed mainly against railroad domination. A stronger economic balance prevails among the various modes of transportation. Antitrust laws would provide an adequate mechanism for preventing anti-competitive practices. Regulatory agencies would still be required to prevent abuses in the industry from occurring. Therefore, restrictions pertaining to intermodal ownership should be relaxed to permit more flexibility and managerial discretion in the use of different transportation modes.

If intermodal ownership should result in the efficiencies its advocates predict, it is possible that independent carriers and carriers in high-cost modes may not be able to compete effectively with intermodal companies. The alternatives for dealing with carriers who lose business to intermodal companies would depend on the importance attached to maintaining the services of these other carriers and this would be a government policy decision. Government subsidies might be provided for these carriers if it were deemed in the public interest for these carriers to provide transportation services. On the other hand, it might be held that the intermodal system was providing the most efficient service and it would not be in the public interest to artificially sustain the operation of less efficient carriers. These carriers might go out of business or assume different roles in the transportation system.

Intermodal ownership possibilities range from bi-modal operations to total transportation companies which include virtually all modes of transportation. Organizational structure can range from separate operating entities related only through joint stock ownership to single management responsibility for all modes. The various types of intermodal ownership which would be feasible in an air cargo system are discussed in the following sections.

3.3.3.4 Common Ownership in an Air Cargo System

The 1977 air cargo deregulation legislation opens the way for common ownership in the air cargo industry. According to Leister and Stram some legal ambiguities remain, but "PL 95-163 permits, certainly within one year, the option of single ownership of all the organizational entities that are required to offer the shipper the complete door-to-door product with the use of scheduled large aircraft" (ref. 24, p. 6).

The most likely changes in the organizational structure of the air cargo system in the near future will involve motor carriers, freight forwarders, and

the airlines. Trucks provide the flexibility of service which aircraft cannot attain. Trucks are widely used to provide supplemental service in air cargo transport, although the effectiveness with which they are used is limited by inefficient ICC common carrier rulings. The deregulation legislation along with changes in ICC rulings (e.g., expansion of 25-mile exempt zone) would permit inter-modal ownership combinations which would improve the efficiency of air cargo transport. A single corporate entity would be able to provide pickup and delivery service, freight consolidation, and line-haul air transport. Because airlines serve a limited number of routes, a single intermodal company would not be able to provide service to all points required by shippers. Since ideally there will be many intermodal companies, interline agreements such as occur in airline passenger transportation, could be arranged to provide service to a wider range of cities. Another possibility would be a new type of freight forwarder who would arrange the optimum routing for a shipment and receive a commission on the traffic generated for a transportation company. (The functions of this agent are discussed in more detail in Section 3.2.2.4). Such reorganization of the transportation industry would affect the trucking industry and the freight forwarding industry. Some of the potential consequences in these industries are discussed in Section 3.5. The truck/air combination is the most probable next step toward intermodal ownership in air transportation. Other intermodal combinations, such as rail/air and water/air will also undoubtedly be applicable in many cases.

This report deals specifically with the design of an air cargo transport system, and, therefore, intermodality is discussed mainly with reference to air transportation. Given the current sentiment in favor of a coordinated transportation system it must be remembered that air transportation is only one part of a transportation system. There are many who argue that in a coordinated transportation system, the best service can be provided by total transportation companies which potentially could own and operate several modes, one of which might be air. The transportation companies would assume the responsibility of selecting the appropriate combination of modes and the optimum routing of shipments. This would not necessarily result in the elimination of independent carriers or single mode carriers. The services offered by these various carriers would differ in the scope of the service provided and the degree of specialization of service offered.

Thus, it is recommended that remaining regulatory and legal restrictions which currently prohibit common ownership of transportation modes be removed. If intermodal ownership is economically feasible and if the resulting service is efficient, this form of transportation organization, possibly including the total transportation company, will exist on its economic merits. Governmental guidelines and anti-trust laws would provide protection against abuses.

3.3.4 International Intermodal Transportation

This report does not deal extensively with regulations concerning international intermodal transportation. The international scene is complicated by varying degrees of political involvement in the transportation industries of different countries. We feel that suggestions pertaining to changes in the national policies of foreign countries are not appropriate in the context of this report. Recommendations are offered for general areas in which changes and

innovations would facilitate international transportation coordination.

International transportation agreements are usually reached through bilateral negotiations or through international transportation organizations such as IATA or ICAO. The international organizations consist of a large number of countries and are usually too unwieldy to reach consensus or make desirable changes in any reasonable length of time. Thus, it is most likely that changes facilitating international intermodal transportation will be attained through bilateral (or possible multilateral) negotiations among governments or among carriers and governments. Emphasis in the following areas will facilitate coordination: development of an international intermodal through bill of lading interchange and pooling of containers, landing rights which would permit aircraft to load or unload cargo on any leg of the flight, negotiations which would permit door-to-door service (such as allowing carriers to operate their own delivery service or use those available to local carriers).

3.4 NOISE CONTROL AND LAND USE

As the use of commercial jet aircraft has grown, there have been increasing efforts by citizens and local governments to restrict or control aircraft noise. Although from the beginning of commercial aviation there has been conflict between localities and the aviation industry over the noise produced by aircraft operations, the present conflict dates from the late 1950's when private air carriers first introduced pure-jet aircraft to the nation's civil airports.

While the noise emitted from jet aircraft measured in decibels, is not necessarily louder, it is of a higher frequency than that of propeller-aircraft. Because of the higher pitch, jet aircraft noise has a disturbing impact at close range. (For a more detailed study, see the 1970 NASA Summer Faculty Program in Engineering Systems Design) (ref. 25). In addition, larger numbers of people are affected by jet noise because of the growth of suburbs around formerly isolated metropolitan airports. Searching for means to protect themselves, those communities have attempted to legislate the abatement of aircraft noise and alternatively have sought injunctive relief against the offending aircraft operations. These local attempts to remedy the noise problem have largely failed because of the current preeminence of federal aviation law.

In addition, the increasing numbers of people who find airports unacceptable as neighbors have made it extremely difficult to find acceptable land for new airport expansion. This failure to find available land, in turn, threatens to seriously hamper the future growth of commercial aviation.

3.4.1 The role of the airport operator

As a preliminary matter to any discussion of regulatory control of airport noise, consideration must be given to the question of which authority is liable for damages suffered by neighboring residents from excessive airport noise. Is it the federal government, the owners of the airplane, or is it the airport owner? In 1962, the question was resolved by the U.S. Supreme Court in Griggs v. Allegheny County (ref. 26).

The court concluded that it was the airport proprietor that was liable to nearby property owners for damages caused to their property by noise from commercial flights when the flights were low enough to constitute the "taking" of an air easement over the property. Essentially, the court reasoned that since the proprietor as a land owner has the ultimate say as to who comes on to the land, he should bear the ultimate burden.

Since Griggs, the real effort towards regulating and reducing airport noise has gotten underway. There has been a sort of balancing out in which the various levels of government have tried to do some regulating but not so much regulating that they are found by the Supreme Court to have the ultimate say, so that Griggs might be overruled and they might become the one saddled with liability (ref. 27, p. 34). Some states have acted affirmatively to

control exposure to aircraft noise through land use control and building design, whereas the FAA, acting to maintain consistency with the Griggs rationale, has avoided assuming responsibility for taking of local noise easements. This may perhaps explain the relative inaction by the federal government in matters connected with airport location and local noise control.

Through enactment of the Federal Aviation Act of 1958, Congress has pre-empted regulations of aviation; therefore, acts by a state or municipality which are inconsistent with this congressional action are prohibited. The principle of preemption in aviation regulation has been developed in a series of cases primarily involving local governments, which dealt specifically with the question of jurisdiction to regulate aircraft noise. The first two of these, Allegheny Airlines, Inc. v. Village of Cedarhurst (ref. 28), and American Airlines v. Town of Hempstead had arisen near what was initially Idlewild and is now Kennedy Airport; a third case, American Airlines v. City of Audubon Park (ref. 30), came up in Kentucky.

These cases held that the local governments which surround an airport and which do not own that airport cannot by police power regulation, whether by height restrictions, noise restrictions, or hour limitations, impose controls which have the effect of regulating aircraft in flight.

In 1973, the Supreme Court in Burbank v. Lockheed Air Terminal, Inc. (ref. 31) upheld the preemption principle as against a locality which did not own the airport. In subsequent cases, however, it was found that a local government could play a role in cases where it was (in whole or part) the airport proprietor. The combined result of these decisions has been that while common sense requires that exclusive control of airspace allocation be concentrated at the national level, thus, communities are preempted from regulating planes in flight, the task of protecting the local population from aircraft noise, has fallen to the agency, usually the local government, that owns and operates the airfield. Therefore, local proprietors have the power to select an airport site, acquire land, assure compatible land use, and control airport design, scheduling and operations--subject only to Constitutional prohibitions against creation of an undue burden on interstate and foreign commerce, unjust discrimination, and interference with exclusive federal regulatory responsibilities over safety and airspace management.

The most recent case addressing the question of the role of the airport proprietor held that local airport proprietors may impose noise requirements for aircraft landing or taking off at their airports provided the regulations are reasonable and nondiscriminatory (ref. 32).

The restriction that an airport proprietor may not unreasonably burden interstate or foreign commerce has given federal agencies--principally the FAA and its parent, the Department of Transportation--considerable leverage in dealing with individual airport proprietors, even where this leverage is exercised only in a "consulting" process. In its 1976 Aviation Noise Abatement Policy, the FAA suggested a procedure modeled after efforts in Boston and Louisville, whereby an airport proprietor in conjunction with local governments, airport users, citizens, and the FAA would develop noise control plans (ref. 33).

the following outline is an excellent list of most or all steps that can presently be taken at the local level (ref. 33, pp. 55-57).

- A. Actions that the airport proprietor can implement directly:
 - (1) location of engine run-up areas;
 - (2) time when engine run-up for maintenance can be done;
 - (3) establishment of landing fees based on aircraft noise emission characteristics or time or day.
- B. Actions that the airport proprietor can implement directly if he has authority, or propose to other appropriate local authorities:
 - (1) plan and control of land use adjacent to the airport by zoning or other appropriate land use controls, such as utility expenditures and the issuance of building permits;
 - (2) enact building codes which require housing and public building in the vicinity of airports to be appropriately insulated; and
 - (3) require appropriate notice of airport noise to the purchasers of real estate.
- C. Actions that the airport proprietor can implement directly in conjunction with other appropriate local authorities and with financial assistance from the FAA, where appropriate:
 - (1) acquire land to insure its use for purposes compatible with airport operations;
 - (2) acquire interests in land, such as easements or air rights, to insure its use for purposes compatible with airport operations;
 - (3) acquire noise suppressing equipment, construction of physical barriers, and landscape for the purpose of reducing the impact of aircraft noise; and
 - (4) undertake airport development, such as new runways or extended runways, that would shift noise away from populated areas or reduce the noise impact overly presently impacted areas.
- D. Actions that the airport proprietor can propose to FAA for implementation at a specific airport as operational noise control procedures:
 - (1) a preferential runway use system;
 - (2) preferential approach and departure flight tracks;
 - (3) a priority runway use system;
 - (4) a rotational runway use system;
 - (5) flight operational procedures such as thrust reduction or maximum climb on takeoff;
 - (6) higher glide slope angles and glide slope intercept altitudes on approach; and

(7) displaced runway threshold.

E. Actions an airport proprietor can establish, after providing an opportunity to airport users, the general public and to FAA to review and advise:

(1) restrictions on the use of or operations at the airport in a particular time period or by aircraft type, such as:

- (a) limiting the number of operations per day of year;
- (b) prohibiting operations at certain hours--curfews;
- (c) prohibiting operation by a particular type or class of aircraft; and

(2) any combination of the above.

F. Actions an airport proprietor can propose to an airline:

- (1) shifting operations to neighboring airports;
- (2) rescheduling of operations by aircraft type or time of day.

3.4.2 The federal role

As indicated in the preceeding pages, the FAA can play a significant role in noise management by consulting with local airport proprietors. It also, however, has a major role to play at another level. The FAA began instituting noise abatement procedures in the early 1960's. The first explicit statutory direction to deal with the problem came in 1968 when the Federal Aviation Act of 1958 was amended to enable the agency to institute noise emission standards as an element of the aircraft certification procedure. This statute gave the FAA broad authority to prescribe rules and regulations for the control and abatement of aircraft noise and sonic boom, and required it, in formulating noise abatement regulations, to consider a number of factors, including whether a proposal requirement is consistent with safety and whether it is "economically reasonable, technologically practicable and appropriate for the type of aircraft, aircraft engine, appliance, or certification to which it will apply" (ref. 34).

In 1972, a second major piece of Federal legislation, the Noise Control Act, strengthened the provisions of the Federal Aviation Act and brought the Environmental Protection Agency (EPA) into the regulation of aircraft noise (ref. 35). This comprehensive enactment was the first venture of the Federal Government into the field of noise pollution control. Under the Act, the EPA is one of the agencies the FAA must consult before adopting noise rules, and except in emergencies, requires consultation with EPA before any exemption is granted under the rules. It contains a prohibition against FAA's granting a new type certificate for any aircraft whose noise could be significantly reduced, unless the FAA has adopted noise standards applicable to the aircraft. It also created a new procedure for joint regulatory action by FAA and EPA, which has led to the enactment of several significant regulations.

As part of its overall aircraft noise and abatement program, the FAA adopted Federal Aviation Regulation Part 36 (FAR 36) in 1969 (ref. 36). It is a comprehensive rule containing highly technical appendixes whose purposes are to require the maximum feasible use of noise control technology, to set standards for the acquisition of noise levels, and to obtain data useful for predicting noise impact in airport neighborhood communities.

Specifically, FAR 36 has prohibited further escalation of aircraft noise levels by establishing noise standards which must be met as a condition for aircraft type certification for all new subsonic turbojet-powered aircraft and subsonic transport category airplanes. As for older aircraft, the Secretary of Transportation has decided that these will have to comply with the regulation by January 1, 1985 either by means of aircraft replacement or retrofitting the engine nacelles (housings) with accoustical material (ref. 37).

FAA regulations also require certain new production subsonic turbojets and subsonic transport category airplanes to comply with noise standards of Part 36, irrespective of the date of type certification as a condition for issuance of airworthiness certificates (ref. 38). (Since the effective date of the regulation, three transport-category turbojet aircraft have been certified-- Boeing 747, McDonnell-Douglass DC-10, and Lockheed L-1011 Tristar.)

The most recent FAA regulations for subsonic transport category large airplanes (over 75,000 pounds) and subsonic turbojet powered airplanes provide for three stages of noise reduction, require new applicants for type certification to comply with noise limitations more stringent than previous regulations and increase the strictness of the accoustical change requirements (ref. 39). The FAA has also adopted noise standards for small propellor driven aircraft (ref. 40, p. 1029).

Pursuant to 49 USCS 1431, the FAA has authority to control aircraft noise by control of aircraft operations such as take off, approaches and flight paths. In this vein, the FAA has proposed regulations to require airports, as a condition of certification, to plan for noise abatement (ref. 37), and the EPA has proposed noise abatement minimum altitudes for turbojet-powered airplanes in terminal areas (ref. 40, p. 1072).

Lastly, the FAA has promulgated regulations which almost completely prohibit the operation of any civil aircraft (the FAA has no authority over military aircraft) over the lands and territorial waters of the United States at greater than supersonic speeds unless authorized by the FAA (for certain research and test purposes) (ref. 41). This regulation virtually bans supersonic flights over the United States with the exception of military aircraft.

To date, the Federal Aviation Act and the Noise Control Act of 1972 are the two major pieces of Federal legislation aimed at aircraft noise. However, more legislative action is likely to follow. While the FAA has recently experienced some success in reducing noise emission standards of aircraft, and will continue to require future aircraft types to fully utilize noise suppression technology, Federal law still fails to deal effectively with the problem of cumulative noise exposure near airports. FAA rules also contain many broad

exceptions. They do not apply to military aircraft nor older types of aircraft, and there has yet to be established effective rules limiting airport noise from supersonic transports (SST's) and vertical and short take-off and landing aircraft (v/stol's). In view of the pervasive scheme to federal regulations and promotion of air commerce, more comprehensive federal action addressed to all areas of aviation seems inevitable.

3.4.3 International Controls

The FAA's rules have very limited application to the international movement of air cargo. The noise standards in FAR 36, apply only to aircraft registered in the United States, including foreign-made aircraft operated by American carriers (ref. 42). In accord with international practice, foreign air carriers need only have their aircraft certified in the country of origin, meeting the noise standards in force there (ref. 43). The FAA's operating rules, including any that it might adopt to control noise, govern the flight within the United States of U.S.-registered aircraft and, in general, of foreign-registered aircraft. When U.S.-registered aircraft are in another country, they follow its flight rules and, except where inconsistent, American rules as well (ref. 44).

The need for international cooperation on aviation rules is met by the Convention on International Civil Aviation, formulated in Chicago in 1944 and ratified by the U.S. in 1946. This multi-lateral convention established the International Civil Aviation Organization (ICAO), a consultative organ through which contracting nations work out coordinated approaches to aviation problems. Through the work of the ICAO, a number of annexes have been added to the convention establishing "international standards and recommended practices," which apply to more than one hundred and twenty contracting nations.

Annex 16 to the convention prescribes noise standards, similar to those in FAR 36, which bind all ICAO members not filing an exception to them. Although Annex 16 has differed slightly from FAR 36 in the past, recent amendments to FAR 36 have brought United States aircraft noise standards into greater conformity with the international standards adopted by the ICAO. These amendments indicate an awareness on the part of the United States of the need to promote equal treatment for foreign and domestic aircraft operations through international standards. Without this equal treatment, unwarranted economic advantages or disadvantages among competitors could be created in a world air transport environment characterized by diverse national noise requirements.

3.4.4 Impacts on the air cargo system

A number of local governments and airport authorities throughout the United States have imposed or are considering imposing special restrictions, including complete curfews, on nighttime airport operations. Such restrictions might have an especially significant impact on air cargo operations. This disruption would occur mainly because the movement of air freight is heaviest at night. Many shippers (e.g. chemicals and allied products industry, agricultural production, electrical equipment and related industries, and the apparel industry) have come to regard "next-day delivery" as essential. Growth of the system

visualized in this report depends heavily on the ability of the shipper to have packages leave his dock at the close of the work day and reach the consignee the following morning.

Despite recognition of the danger to the air cargo industry from restrictions on night operations, little effort has been put into determining the magnitude of the impacts which may result. To what extent would extensive nighttime restrictions hamper the air cargo industry, the industries that ship their raw materials and products by air, the regions housing these industries, or the U.S. economy as a whole? A recent study by the Port Authority of New York and New Jersey may suggest some dimensions of the problem (ref. 45). While a limited study, it still presents a glimpse of the air cargo industry as it is structured today and how it is likely to be initially affected by airport nighttime restrictions. Further, it provides the basis for studying the flows of aircraft between major national markets, the impacts of curfews on shippers and consignees and, therefore, insight into the nature and magnitude of some of the problems that may result.

Some of the early analysis work of the survey indicates the following about the New York/New Jersey air freight picture.

1. About 35 percent of all Kennedy/Newark Airport freight moves between 10 p.m. and 7 a.m. (472,000 tons in 1977).
2. "All Cargo" aircraft haul about 94 percent of all nighttime tonnage (444,000 tons in 1977).
3. About 28 percent of all nighttime tonnage (132,000 tons in 1977) was transfer freight, some final destination.
4. 61 percent of all New York/New Jersey regional all-cargo activity occurs between 10 p.m. and 7 a.m.
5. Freighters move most of the cargo originating in the five major originating cities. For example, freighters move about 67 percent of Los Angeles' daily tonnage to New York, 86 percent of San Francisco's, about 100 percent of Chicago's, about 100 percent of Seattle's and about 95 percent of San Jose's.
6. Overseas air cargo movement would probably be less affected by nighttime restrictions. Only 22 percent of the overseas tonnage moves between 10 p.m. and 7 a.m. But whatever moves at night moves mostly on freighters (92 percent of total nighttime tonnage moves on freighters).

From this data, one can see that nighttime use restrictions, such as curfews, might have a major detrimental impact on air freight shipment. For this reason, it is easy to understand why the FAA and other proponents of the national air transportation system do not "promote" curfews, but in fact, recommend that proprietor's first consider other approaches (i.e., zoning, noise barrier, engine run-up areas) to abating the noise at their airports.

3.4.5 Future prospects

It is obvious that government at all levels is involved to some extent in aviation noise control. State and local governments, as airport proprietors or through guidance to proprietors, have taken the lead in measures to reduce the impact of noise on people on whom it can have an effect in the near term. The exclusion of noisy aircraft, limitation on number of flights, and constraints on times of flights are all tools used by innovative proprietors faced with the difficult task of balancing the benefits of aircommerce with the equally pressing need to diminish the effect of noise pollution on the people who live and work near airports.

The federal government, on the other hand, while it has taken the lead in regulating the manufacture of aircraft so as to insure greater quiet, is in a paradoxical position. If it joins in the fight in a major way to reduce aircraft noise pollution at airports, it runs the risk of occasioning a reversal of Griggs and a federal assumption of billions of dollars of liability. If it takes more modest steps in the area, it runs the risk of preempting the efforts of state and local governments without substituting anything meaningful for them (ref. 27, p. 36).

It seems inevitable that this split in responsibility will continue, although it seems probably and desirable that there be increased coordination. We expect that the "consultation" process between the FAA and individual airports will be increasingly formalized and that this will promote a tendency to more uniform local practices.

The local and state governments will continue to have the primary responsibility for finding land to locate new airports and expanding existing airports. These difficulties, like those of locating new power plants, presently seem nearly insurmountable and will require substantial innovative thinking. For instance, it has been suggested that some percentage of the tax revenues generated by a new facility could be set aside to provide substantial benefits to residents of the area adversely affected by proximity to the new facility: a town or county might be more willing to permit a new airport to be located in or near it if it meant a substantially lower tax rate.

In regard to aircraft design and aircraft and airport operations, cooperation between all parties (manufacturers, air carriers, airports, and governments at all levels) will remain necessary. Advocates of an enlarged air cargo system must not be blind to the effects of nighttime aircraft operations on surrounding communities. They must use aircraft which utilize the most advanced noise suppression technology and try to schedule flights during hours which would be least offensive to local residents. Local residents and other interested parties must, however, realize that for the air cargo system to function economically, it must be able to land and take off from airports at night. For maximum growth of the air cargo industry, it is essential to maximize the number of cities which can accommodate night flights by cargo planes. Two actions will contribute to this. First, we urge that the FAA work to avoid absolute prohibitions on night operations or restrictions that would effectively prevent night cargo flights. Second, we urge that the developers of a new mid-range cargo aircraft (of the general type described in Chapter 2) pay careful attention to the fact

that it must fly into small airports at night and that it must satisfy noise restrictions appropriate to that circumstance. Further, the imposition of nighttime restrictions, especially curfews, on a national basis would result in a bunching of flights in those hours immediately preceeding the curfew. This would have the two-fold effect of increasing an already serious congestion problem and actually increasing, rather than relieving, the noise problem by increasing the number of flights in the time prior to the curfew. Such a result would be totally inconsistent with the objectives of the federal statutory and regulatory scheme and would cause a serious loss of efficiency in the use of the navigable air space.

3.5 IMPACTS

3.5.1 Introduction

Conditions in the U.S. airline industry today are to a great extent the result of government regulation. Therefore, the recent deregulatory changes will have both direct and indirect impacts on the airline industry, related transportation industries, and the overall transportation system. There is considerable disagreement as well as a lack of historical precedent regarding the exact extent and degree of impact these changes will have. This concluding section attempts to describe what are considered to be some of the potential impacts of these regulatory changes on various segments of society.

The major regulatory changes pertinent to this study are (1) economic deregulation of the airline industry, which includes legislative and regulatory changes, (2) noise regulation, and (3) regulatory changes which have been recommended by the design team, but which are not yet in progress. Since most of the impacts are discussed in more detail in other parts of this report, in this section a brief summary of each impact with the appropriate cross-reference is given.

3.5.2 Impacts of Economic Deregulation

Organizational Impacts. Organizational impacts resulting from deregulation will be most evident in the formation of multi-modal transportation companies. In the short term the most probably intermodal combination in the air cargo industry will involve airlines, freight forwarders, and motor carriers. The long term result, if dictated by economies of scale, will be totally integrated transportation companies (Section 3.5.3.3). A new type of company in air cargo transport which would provide services analogous to those provided by travel agents in passenger service has been suggested (Section 3.2.2.4).

Impacts on Airline Route Systems. The major effect of deregulation on airline route systems will be to allow increased managerial discretion in selecting routes to be served. Airlines will be able to expand their route systems and make route changes necessary to improve operating efficiency. Freedom to own and operate other modes of transportation will increase the number of points served and in effect greatly expand the air cargo route system (Section 3.2.1.2).

Impacts on Service to the Shipper. The increased flexibility of routes and rates permitted by deregulation will encourage carriers to be more responsive to the demands of shippers. Free entry into the industry will provide the environment necessary for price competition. Intermodal operations will increase the number of points served. The combination of these factors should result in overall improvements of service to shippers. Some negative impacts of deregulation are an increase in rates for services which require special handling or for which there is little demand (Section 3.2.2.2) and the reduced liability of carriers under deregulation (Section 5.2.1.4).

Impacts on Employment. There is some concern that deregulation will result in loss of jobs in the transportation industries. The reasons given for

the potential unemployment are varied and include: Job losses resulting from mergers and consolidations, jobs losses resulting from the financial difficulties that some firms would experience after deregulation, and displacement of motor carriers and independent carriers that might result from a restructuring of the transportation industries. Others predict that deregulation will result in increased air traffic which will result in additional jobs. The most probable effect will be: Some unemployment will result for the reasons mentioned above, but additional jobs will be created in the airline and aircraft industries, as well as in other areas of the transportation system. Thus, the overall impact of deregulation on employment will be favorable.

Impacts on Capital Formation. The uncertainties associated with a deregulated environment will result in some initial reluctance on the part of investors to provide capital. However, deregulation will encourage managerial efficiency, which will increase profitability and improve the financial situation of the airline industry. The resulting higher proportion of internally generated capital funds will increase the attractiveness of the airline industry to investors. Thus, although in the short run deregulation is likely to have a somewhat negative impact on capital formation, in the long run it will have a positive impact (Section 4).

Impacts on Subsidies. Transportation subsidies are difficult to analyze. There are problems in determining the amount of subsidies in the various modes and the necessity for such subsidies. Subsidized service in the airline industry is likely to continue under deregulation, since the airline deregulation bill pending in Congress contains a provision which will guarantee "necessary air service to communities" (ref. 46). Services for some types of air cargo might also be deemed necessary (Section 3.2.2.2), and it might be determined in the public interest to provide subsidies for certain modes (Section 5.3.3.3). It has been argued that intermodal ownership would reduce the needs for some government subsidies (3.3.3.3). Thus, direct government subsidies will continue after deregulation, but the extent will depend upon policy decisions which meet the needs of the public interest.

3.5.3 Impacts of Noise Regulation

Impacts on Air Freight. One means of resolving the noise pollution issue around airports has been the imposition of restriction on nighttime airport operations. Since the optimum scheduling of air freight movements is for night flights, curfews restricting nighttime operations will have a detrimental effect on air freight shipments. The result of a preliminary analysis of the impacts of curfews are discussed in Section 3.4.4.

Impacts on the Economic Obsolescence of Older Aircraft. The Secretary of Transportation has decided that older aircraft will have to comply with new noise regulations by January 1, 1985, either through aircraft replacement or retrofit with quiet engines. It has been estimated that approximately 1200 aircraft operated by the domestic trunks and Pan Am will not meet federal noise standards (ref. 47, p. 4). An estimated cost of retrofitting aircraft in service in mid-1972 was given at \$456 million (ref. 48, p. 302). Thus, the impact of noise requirements is to increase the capital requirements of the airline industry.

3.5.4 Impacts Resulting from Recommended Changes

The following are positive impacts which we believe would be the result of our recommendations in the legislative and regulatory areas.

1. A restructuring of the regulatory organization into a single agency with functional rather than modal divisions.
2. The attainment of a coordinated transportation system by encouraging the use of a single bill of lading and relaxing restrictions on pick-up and delivery zones.
3. A guaranteed level of service to the shipper by requiring minimum insurance provisions, carrier liability provisions, and preservation of the capability of the national transportation system to handle some classes of special cargo.

3.5.5 Summary

The impacts resulting from legislative and regulatory changes are complex and there is considerable disagreement on what form these impacts will actually take. Because of time limitations, only a brief discussion of these impacts is given in this section, and the most probable impacts as suggested by this study have been presented.

3.6 CONCLUSIONS

In view of recent developments, including the extensive deregulation of air cargo operations as well as changes in airport curfews and continuing noise control efforts, long-term predictions about the impact of regulatory practices on the air cargo industry are exceedingly difficult to make. There is significant difference among analysts regarding the extent and duration of the deregulatory movement. On the other hand, there is general agreement that at least some degree of regulation will continue well into the twenty-first century. Certainly there will continue to be extensive regulation of such matters as safety standards and noise. The major issue is whether or not the regulatory climate will be a force for or against the development of a relatively unified, efficient, and rational transportation system.

The air cargo system can make its most effective contribution if the transportation network is seen as a unified system. It appears that this can be best achieved by unifying national transportation standards and policies--most logically through a unified regulatory agency--and by sufficiently relaxed regulation to allow the marketplace to develop new corporate structures and merchandising methods appropriate to a unified system.

Even the complete elimination of all regulatory constraints would leave substantial problems, resulting from present institutionalized practices, the fragmented nature of the transportation industry, and the contending pressures of special interest groups. Still, appropriate easing and simplifying of regulations will encourage--or at least remove present obstacles to--the evolution of an integrated intermodal freight transportation system in which the air cargo system described in this report can play its optimal role.

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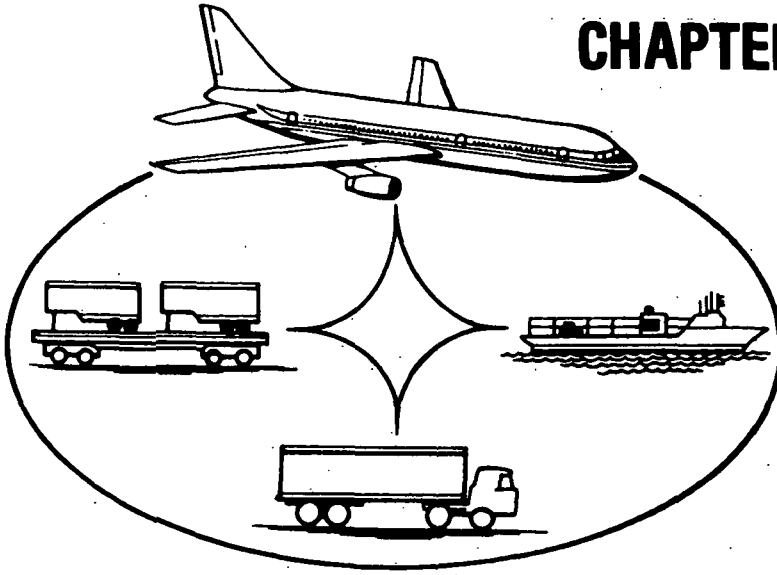
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CHAPTER 4



PUBLIC POLICY

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CHAPTER 4

PUBLIC POLICY

Introduction

Public policy issues which relate to the air cargo integrated system are basically issues of energy, economics, and politics. The energy picture must be displayed; the economic considerations must be explicated; and the political ambiance in which decisions occur must be defined if we are to comprehend the global significance of the ACIS. These three concerns are not separate in fact, and not easily separable in theory. Therefore, even though the separate sections in Chapter 4 may focus on one of the three central aspects, the discussions are not "topic tight".

Section one of our chapter addresses American political culture as it relates to the ACIS. Section two is most easily characterized as the economics of materials and energy. Section three relates the concerns of the preceeding section to policy issues. Capital formation is the primary focus of Section four. Section five addresses military needs and foreign policy. Finally, in Section six, we discuss futures and impacts of the ACIS.

4.1 PHILOSOPHY OF GOVERNMENTAL ACTIVITY

It appears that an integrated air cargo system cannot be put in place without government playing a facilitating role. This facilitating role includes the establishing of an appropriate set of regulations; institutions for implementing those regulations; and the creation of an economic climate wherein business can function in conformity to those regulations. In playing its facilitating role, the government must see that the public interest is served and thereby legitimate its involvement.

While there exists a wide range of opinion about what is and is not in the public interest, consensus prevails among Americans regarding the necessity of provision for public goods. In explicating the notion of public good John Rawls says ". . . the main idea is that a public good has two characteristic features, indivisibility and publicness. That is, there are many individuals, a public so to speak, who want more or less of this good, but if they are to enjoy it at all, they must enjoy the same amount. The quantity produced cannot be divided up as private goods can and purchased by individuals according to their preferences for more and less. There are various kinds of public goods depending upon their degree of indivisibility and the size of the relevant public." (ref. 1) The consequence of indivisibility and publicness is that public good must be provided for through the political process rather than the market. Thus if it can be shown that the public good derived from an integrated cargo system is worth the public portion of the money used to put such a system in place then the government is justified, on these grounds alone, in acting to implement the ACIS.

When we attempt to access the public good that will be derived from the ACIS, we are immediately confronted with the difficulty of forecasting future trends and guarding against undesirable outcomes. That is, we want to have a system which will be politically and economically acceptable if things go as planned, but we also want to avoid catastrophic consequences if things do not go as planned. We ask ourselves, "What will happen if the economy grows much faster, or much slower, than expected -- What are the disbenefits associated with overcapacity and undercapacity?"

We do not view the system here proposed as a conservative one. We have already advocated major changes in the terminal system, in the structure of regulatory agencies, and other facets, and have foreseen a major and important industry, growing where only a few years ago there was only a minor business; a poor relation of passenger carriage. On the other hand, we have not adopted the views advocated by some that there should be, by the turn of the century, huge distributed-load aircraft or other major technological changes involving truly massive public and private investment. Is this being unduly conservative? The answer to this question lies in viewing the consequences of misjudgement, and foreseeing corrective measures.

Figure 4.1 introduces the concept of consumer's surplus (ref. 2). The curve labeled D is the hypothetical demand curve. Following the curve from right to left we see that as the price increases, the demand goes down. The curve labeled C represents the cost of service. At some point, curve C crosses curve D. In an unconstrained market, we would expect the quantity of services available to be determined by the intersection of curves C and D.

If the capacity of the system exceeds market demand, then the quantity of consumer surplus benefits is little affected and the disbenefits of the excessively large system will be borne in part by the government. But, if capacity is less than market demand then the mechanism utilized to bring demand into line with supply is worthy of analysis in terms of public benefits.

If market demand exceeds capacity and users are accommodated on a first-come, first-serve basis, then the overloading of the system will create a population of randomly selected dissatisfied users. These users will be less inclined to use the air transport system and therefore quantity of goods moved will decline. The randomly distributed instances of poor service has the effect of increasing the cost to the users. (See Figure 4.2)

If, instead of relying on customer dissatisfaction to limit demand, a tax is placed upon the system which has an equivalent constraining effect, the picture changes considerably. In Figure 4.3, the price to the user is shifted with the addition of the tax. The result is that most of the consumer surplus lost due to undercapacity is transferred to the government and is available for investments to correct the situation or for other public uses.

Since the government will presumably be able to impose a tax at its discretion, should market demand exceed capacity, it follows that in planning air cargo futures, the federal government, in its role as guardian of the public interest, should opt for the smallest practical system. The cost of overcapacity cannot be recovered while the cost of undercapacity can be made to translate into considerable public benefits.

In trying to fulfill the government's role, decision makers must work within the framework of American political culture (ref. 3). It is therefore appropriate to look at four specific features of American political culture which define parameters for decision makers (ref. 4). The four features are:

1. Belief in a limited role for government in relation to economic enterprise
2. Distrust of centralized decision making in government
3. Ethnocentric orientation toward institutions
4. Emphasis upon pluralistic public decision making

It is plausible to expect that the American public and public sensitive decision makers will emphasize a limited role for government in relation to the ACIS. Therefore, such options as creating a public corporation to

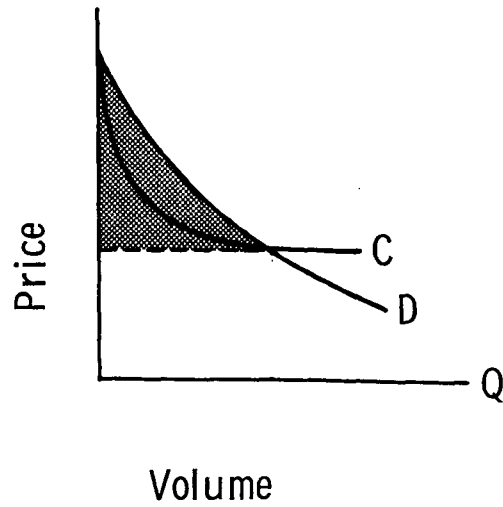


Figure 4.1 VOLUME REGULATING MECHANISM

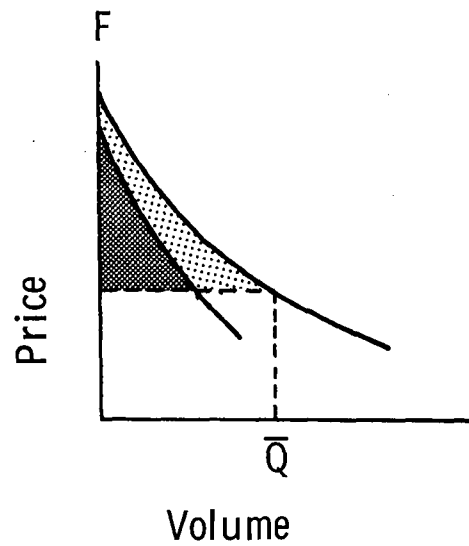
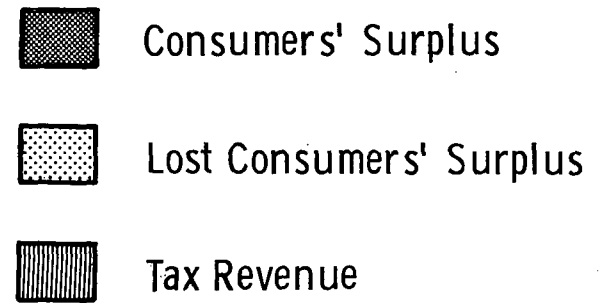


Figure 4.2 VOLUME REGULATING MECHANISM

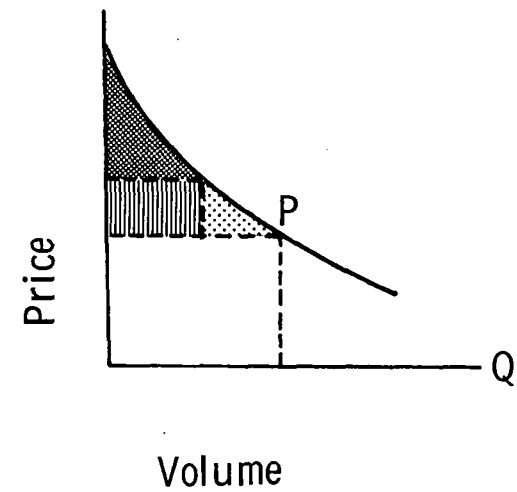


Figure 4.3 VOLUME REGULATING MECHANISM

manufacture advanced aircraft may be difficult to exercise. It can also be expected that there will be considerable resistance to the formation of international companies for either aircraft manufacturing or freight movement. Therefore, capitalization will be difficult and the efficiencies achieved by single waybill difficult to realize in the international sphere.

American political culture also operates to produce a diffuse decision making process wherein each administrative agency jealously guards its prerogatives (ref. 5). This factor tends to further augment the likelihood that non-optimal decisions will be made concerning the ACIS unless a concerted planning effort is made.

The diagram in Figure 4.4 attempts to identify the principal participants in the policy making process that involves a national decision on advanced air cargo aircraft. As the figure indicates, input concerning policy initiative comes primarily from aircraft manufacture, the military, and commercial group lobbies. One can expect lesser involvement by government agencies such as EPA, DOT, DOE, NASA, etc., and state and local government. (ref. 6) All such interests may influence the introduction of legislation and the adoption of regulations relating to the ACIS. Once the legislative process is underway, congressional staff members, lobbies, and the GAO have considerable impact (ref. 7).

The systematic implications of this diffuse and pluralistic process are that a vast complex of goals and interests will have to be taken into account when public policy is formulated with respect to the ACIS. A reconciliation of all interests may not be feasible and unhappy compromise decisions may be made. Under these conditions, optimal solutions may be difficult. Therefore, persons looking for the best decision with respect to the ACIS could be somewhat disappointed.

The combined effects of the legitimating rationale which must be offered for the development of the ACIS and the political ambience, or culture, wherein decisions about developing the system must be made are such that undesired outcomes are likely unless concerted and clear planning is undertaken. We must decide what we want to do in some comprehensive fashion, but the current energy situation increases the risk of resource commitment. Therefore, we now turn to a consideration of natural resources and the role of transport in the U.S. economy.

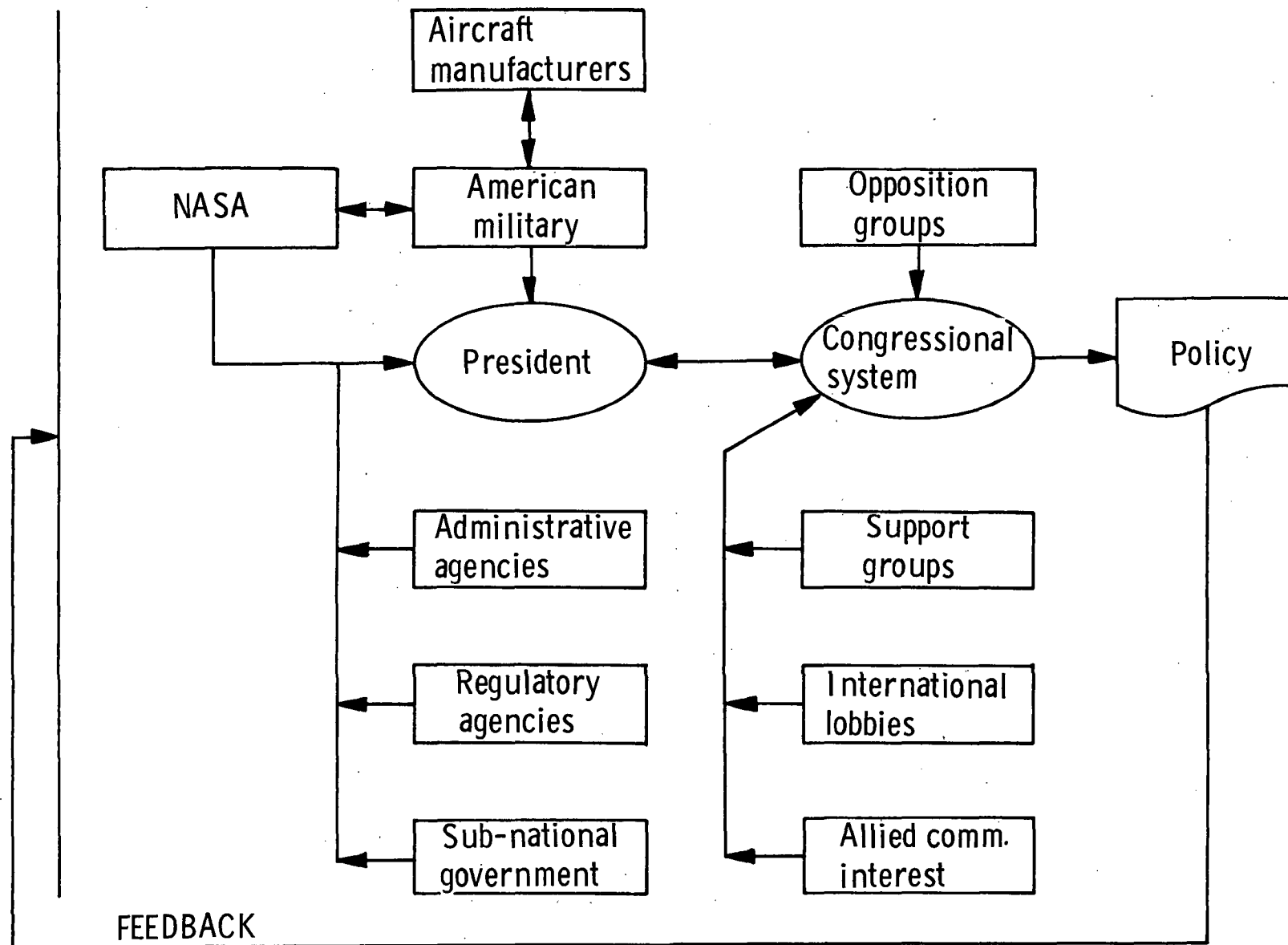


Figure 4.4 NATIONAL POLICY ON ADVANCED AIR CARGO - A SCHEMATIC VIEW OF POLICY PARTICIPANTS

4.2 MINERAL RESOURCES AND THE AIR CARGO INTEGRATED SYSTEM

Introduction

The need to use many different natural resources (Table 4.1) in the actual construction of the Air Cargo Integrated System (ACIS) is certain. Therefore, while it is true that the actual percentage of most natural resources to be used will be small, this small use must be determined so an awareness of the possibility that any particular material will not be available due to depletion or administrative regulation is known.

During the OPEC embargo, the amount of petroleum available to the airlines was drastically curtailed. When shortages of non-renewable resources (NRR) occur, it is logical to assume that the use of these NRR will likely be curtailed. By attempting to determine how much NRR are used by the airline industry and the ACIS specifically, and trying to implement conservation techniques now, it may be possible to avoid critical shortages during the planning period.

The number of different natural resources are great. This study will examine only those natural resources where shortage is likely to occur during the time frame of the overall study. This narrows the natural resources to be studied to certain mineral resources (Table 4.1).

This analysis separates the fuel and nonfuel mineral resources. Although there are many similarities in the basic characteristics and policy implications of fuel and nonfuel minerals, today's market, with its prospects of massive transformation in the fuel sector, introduces important differences that warrant special treatment.

4.2.1. Non-Fuel Mineral Resources

The five major metal minerals used by the U.S. Transportation sector in 1970 are shown in Table 4.2. Although these figures include general aviation aircraft as well as the major airlines and military aircraft, it is evident that the aircraft industry, especially the air cargo industry, uses a substantial amount of mineral resources.

The different minerals used in aircraft are of a greater range than in other transportation modes due to the unique operating conditions. Aluminum, steel, and special alloys of titanium and magnesium constitute more than 70 percent of most aircraft by percent of the total weight (Table 4.3). In addition, a variety of other minerals are present in smaller, but certainly not less important quantities: beryllium, boron, cadmium, carbon, chromium, cobalt, graphite, gold, lead, molybdenum, nickel, silver, tin, tungsten, vanadium, zinc, and zirconium.

Table 4.1

NATURAL RESOURCES

Air	Aesthetics
Minerals*	Product of Land
Fuels*	Crops
Hydrocarbon	Livestock
Non-hydrocarbon	Space
Metallics*	Timber
Non-metallics*	Water

* Those natural resources to be studied in this section of the ACIS study.

Table 4.2

METAL MINERAL RESOURCE USE BY
THE UNITED STATES TRANSPORTATION SECTOR
(1970 DATA)

Wt. in 10 ⁵ Metric Tons	Steel		Aluminum		Copper		Lead		Zinc	
	%	wt.	%	wt.	%	wt.	%	wt.	%	wt.
Highway Vehicles	19.6	20.19	11.2	0.67	8.2	0.25	00.0	0.60	19.5	0.39
Aircraft	2.2	2.27	6.1	0.37	3.0	0.09	4.3	0.04	4.1	0.08
Ships	1.0	1.03	4.6	0.28	0.8	0.02	1.2	0.01		
Others	4.0	4.12								

NOTES: Copper includes alloys. Lead consumption includes amount used in anti-knock compounds and replacement batteries.

Sources: Kay and Mirrlees, 1975 (ref. 7) and Leach, 1972, (ref. 8).

Table 4.3

THE COMPOSITION OF VARIOUS AIRCRAFT
(Percent by Weight)

	Aluminum Based Alloys	Steels	Titanium Alloys	Copper	Magnesium Alloys	Nickel Based Alloys	Non-Metallics
B.A.C. 111 ²	54-56	25-27	0.1-0.5	1.5-2.5	1.0-1.5	1.0-1.5	
DC 3	80 ³						20 (15% wood fibre)
Concorde	71 ¹	16	4			2	7
747	75 ³		15				10
Unnamed Supersonic	48.2	21.8	8.0	2.6			6.6
Unnamed Subsonic	55.6	26.3	0.5	2.1			12.7

Sources: Edwards, 1970; Alexander, 1972; and Goldsmith, 1974; Vaccari, 1969.

- Note: 1. The aluminum alloy contains 2% copper, 1.5% magnesium, and 1% nickel.
 2. Figures refer to materials bought for the aircraft and include that on the floor as waste.
 3. Percent includes both aluminum based alloys and steel.

The choice of materials is influenced more by the technical properties of the materials than by price considerations. This is due to the small proportion of the total cost of an aircraft that materials make up. Moore (ref. 8) states that the cost of a 747 would only increase by 16 percent if the materials used increased five fold.

4.2.1.1. Availability of the Non-Fuel Mineral Resources for the ACIS

The U.S. is nearing the end of the second of a three stage development in mineral resources. From a past period when the U.S. was abundantly supplied by itself and the world, to the present period when the U.S. must share the world's supply more uniformly with the rest of the world, to the near-future period where the world's mineral supplies are not adequate for the world and some countries must do without depending on their military, resource, and/or economic strength. "The outlook is for an acceleration of demand, increasing difficulty of supply, and increasing challenge to technology, and an upward pressure on prices." (ref. 9)

Table 4.4 illustrates the minerals, divided into metals and non-metals, needed for the three parts of the ACIS system. Their importance to each part of the system is indicated by a number sequence: 3 for important, 2 for moderate importance, and 1 for low importance. A letter indicates those minerals which may have supply problems in the 1990-2015 time period due to possible cartel action (x), price difficulty (y), or depletion-world (z) and U.S. depletion (w).

The three possible types of supply problems were investigated and determined by using the following seven characteristics as well as the author's previous research:

1. The proportion of imports to domestic consumption
2. Vulnerability to coordinated producer action
3. The availability of alternative materials
4. Development of and the amount of domestic resources
5. Imposition of conservation measures
6. The balance of payments impact
7. The capital requirements for domestic and alternative foreign resource development

In dollar value, the U.S. produces about 85 percent of its total mineral needs; yet, despite this success, the U.S. has not been able to correct its mineral deficiencies and has fallen steadily behind in its ability to supply its needs. Of 40 primary minerals needed by the U.S., 20 of them are in jeopardy of being depleted. Approximately 1/3 of the country's net supply of primary metals and metallic ores are imported. The increasing problem of the

Table 4.4

MINERAL RESOURCES NEEDED FOR THE ACIS

General Type of Mineral	Specific Type of Mineral	Aircraft Needs	Terminal and Ground Support Needs	Supply Problem
Metals				
Iron	Iron Ore	2	3	
	Steel	3	3	
Iron Alloy	Manganese	2	1	x
	Chromium	3/2	1	xw
	Nickel	3/2	3	x
	Molybdenum	2	2	
	Cobalt	2	2	x
	Vanadium	2	1	
	Tungsten	3/2	2	x
Base	Copper	3	3	y
	Lead	3	3	z
	Zinc	3	3	y
	Tin	3/2	2	xzw
Light	Aluminum	3	3	x
	Magnesium	3	3	
	Titanium	3	1	x
Precious	Gold	2	1	
	Silver	1	1	zw
	Platinum	2	1	zw
Rare	Uranium	*1		
	Beryllium	2	1	
	Zirconium	3/2	1	
	Mercury	2	1	xzw

Table 4.4 (continued)

MINERAL RESOURCES NEEDED FOR THE ACIS

General Type of Mineral/s	Specific Type of Commodity	Aircraft Needs	Terminal and Ground Support Needs	Supply Problem
Non-metals				
Ceramic	Clay	1	2	
Insulant	Asbestos	2	1	z
	Mica	2		*
Gas	Helium	* ³	* ³	z
	Hydrogen	* ⁴	* ⁴	
	Nitrogen	1	1	
	Oxygen	1	1	
Building	Sand and Gravel		3	
	Limestone		3	
	Cement materials		3	
Chemical	Sulfur		1	
	Salt		2	
Pigment and Filler	Clay	1	2	
	Diatomite		1	
	Barite	1	1	y
Artificial	Plastics	3	3	
	Glasses	2	3	
	Composites	* ⁵		

- Notes: 1. If a nuclear aircraft is developed uranium will be 3 to 2 rating, otherwise uranium will not be a factor.
 3 & 4. If hydrogen is used as a fuel in future airplanes hydrogen will become a 3.
 5. At the present it is 1 but as composites become used more for aircraft construction it will develop into a 3.

U.S.'s developing deficit of minerals is illustrated in Figure 4.5. Specifically the reserve situation is somewhat tight or critical for several minerals. Asbestos, chromium, mercury, and tungsten will be near depletion by 2015. Price increases and difficulty of supply will occur with aluminum, copper, gold, lead, manganese, nickel, and silver. There is a possibility of short supply of barite, iron, mica, phosphate, thorium, titanium; vanadium, and zinc; the extent of the shortage depends on technological supply.

Therefore, the U.S. will become increasingly dependent on foreign sources. Assuming no political problems with obtaining necessary minerals, what is the likelihood that the world's mineral supply will be able to meet the United States needs? Except for asbestos and mercury, the possibility of the world running out of necessary mineral resources from 1990 to 2015 is very unlikely. However, there is a strong possibility of political controls being placed on certain critical minerals. Therefore, it is not the problem of depletion but one of political and in some cases economic controls that will cause the U.S. and the ACIS problems in obtaining the necessary minerals for development.

4.2.1.2. Solutions to the Mineral Supply Problems

What can be done about the U.S. mineral supply problem?

Besides the advancement of technology to use lesser grades of minerals, there are five other possible solutions to the U.S. mineral problem: (1) substitution of abundant for scarce minerals and in certain situations just the reverse, (2) stockpiling of possible problem minerals, (3) recycling of the mineral content of products, (4) changes in product design to increase the useful life of a product, and (5) develop new techniques to find undiscovered mineral deposits. For depletion, true depletion, where our technology cannot make lower grade "ores" feasible to utilize, substitution is a possible solution. Table 4.5 shows some of the more important materials and the possible substitutes that will be used in the construction of the ACIS. Of course, where a mineral has specialized technological applications in which a multiplicity of properties is required as will be the case in the use of many of the minerals for the ACIS, available substitute materials will be more limited than in many other industries.

To reduce the risk of being cut off from necessary mineral supplies, stockpiles of many minerals should be maintained. They may be developed by individual industries as well as the national government for the reality of world trade dictates that industries dependent in significant measure on imported minerals should try to carry substantial inventories of needed raw and semiprocessed materials.

The efficiency of recycling to decrease the U.S.'s mineral supply problems depends on the particular mineral; aluminum, steel, copper, and lead are the leading minerals to be recycled. However, until transportation regulations and federal economic controls are revised, it is unlikely that recycling of minerals will increase for any of these minerals.

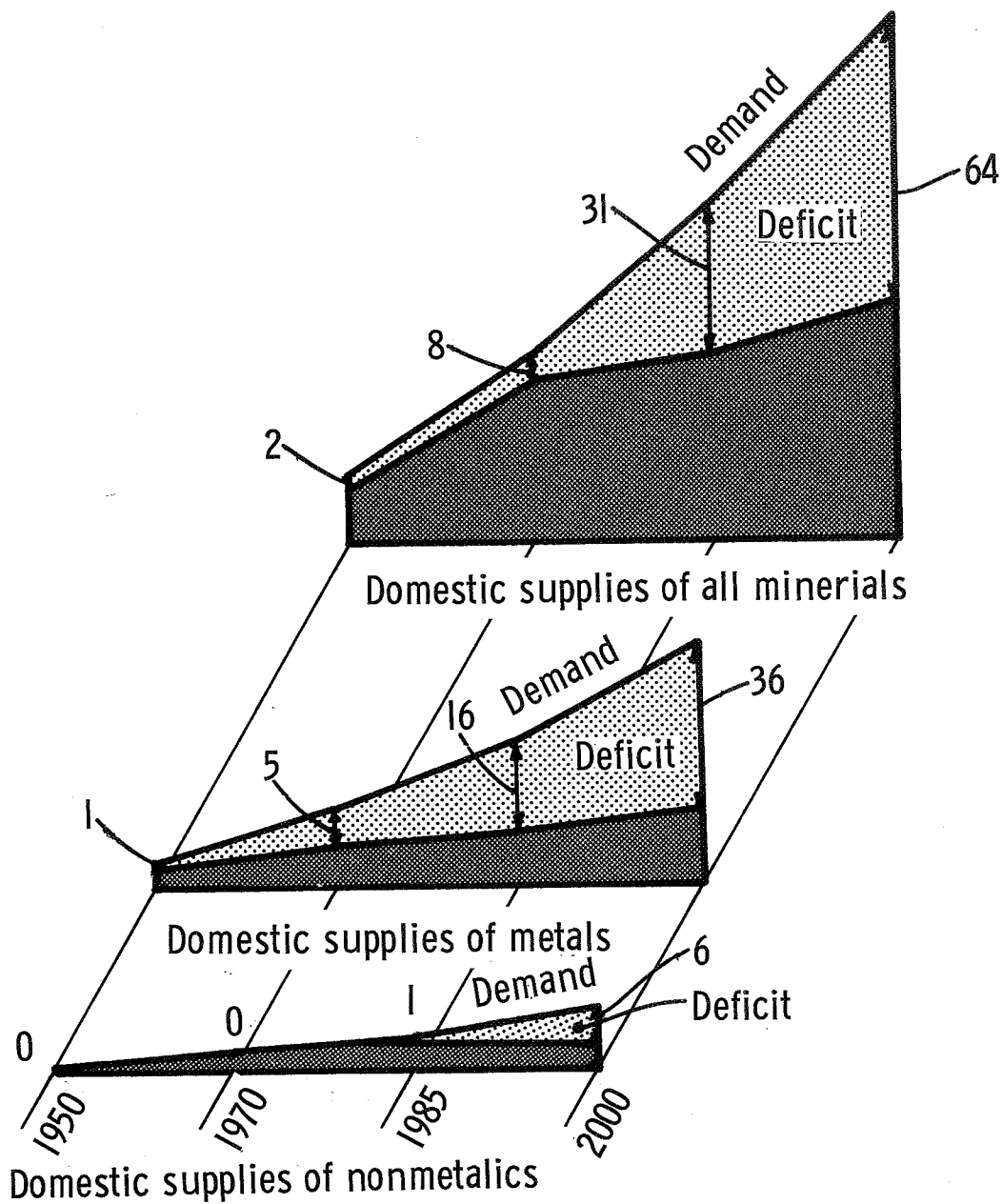


Figure 4.5 THE UNITED STATES INCREASING MINERAL DEFICIT (Source: Adopted from Cameron, 1973, (Ref. 18).

Table 4.5

SUBSTITUTES FOR SELECTED MINERALS

Mineral	Reserves of Principle Substitute Minerals (Years of supply availability)			Other Substitute Products
	Less than 30	30 to 60	100 or more	
Bauxite	Copper Titanium		Steel	Plastic Wood
Chromium		Nickel Molybdenum	Vanadium	
Cobalt		Nickel		
Copper		Aluminum	Steel	Plastics
Lead	Copper Mercury Silver Titanium Zinc	Nickel	Cadmium Zinc	Plastics Rubber Tile
Platinum		Gold		
Tin	Copper Lead	Aluminum Gold	Steel	Glass Paper
Tungsten	Titanium	Cobalt Nickel Molybdenum	Tantalum	
Zinc		Aluminum	Cadmium Magnesium Steel	Plastics

There are many serious problems concerning the U.S.'s mineral resources. Only a few have been addressed in this report; however, Table 4.6 attempts to illustrate many of the problems, which due to space and time constraints, were not addressed in the text.

In view of the geologic and geochemical constraints on the occurrence of economic deposits of minerals and energy resources, and the advanced nature of present exploitation techniques, we must conclude that such resources are finite. On the other hand, the question "When will we run out?" indicates a misunderstanding of geologic resource limits. The world will not run out of many mineral resources, but they will become more expensive and difficult to obtain.

4.2.2. Fuel Resources for the ACIS

There are many sources of fuel for the ACIS; however, at the present time only natural hydrocarbons, specifically petroleum derived kerosenes, are used as fuel in aircraft. Because of this situation, discussion of petroleum resources is an appropriate starting point for this section.

4.2.2.1. World Petroleum

Energy is the lifeblood of an industrial society. It substitutes the power of matter for the power of man. Industrial development and the growth of revenues are linked to the use of various sources and forms of energy. Much of the energy produced originates from fossilized hydrocarbons which are completely consumed in their first using. The amount of available fossil energy, its cost, and the mastery of technologies of extraction, treatment, and dispatching to make it readily available are all factors of power and wealth. Therefore, one of the most critical questions facing the world is: how long will the production of oil continue to be the most important source of energy?

It is hard to overdramatize the importance of oil as a world energy source. If the supply of petroleum could continue to increase indefinitely, the world would continue to use it as the major source of energy; however, because petroleum is a non-renewable fuel it will be depleted in the future. This situation is the principle reason for the "energy crisis". To understand this crisis, it is necessary to understand some of the underlying facts and data.

From the early 1940's to 1975 the estimated crude oil world resources have grown from 400×10^9 barrels to 2000×10^9 barrels (ref. 10). However, the 200 figure was first quoted in 1959 and it has not varied more than 20 percent since that time. The amount of reserves totaled between 600 and 700 billion barrels. Of this amount, 80 percent is in OPEC countries and 80 percent of this amount is in the Middle East (ref. 10). These estimates only include those resources recoverable at current prices and with current technology and therefore include oil recoverable by primary production plus oil recoverable by secondary or tertiary recovery where the potential has been evaluated and facilities are planned.

Table 4.6

Key to numbers:

4 = Very serious

3 = Serious

2 = Moderate

1 = Minor

No number = No problem

MINERAL PROBLEMS: 1976 TO 2015

	Aluminum	Asbestos	Beryllium	Cadmium	Chromium	Clays	Cobalt	Columbium	Copper	Gold	Graphite	Iron Ore	Lead	Magnesium	Manganese	Mercury
World resource inadequacy, by 2015		4								2	2					
U.S. high-grade resource inadequacy, by 2015	4	4	1	4	4	1	3	4	2	4	3	4	2		4	
U.S. low-grade resource inadequacy, by 2015					4		2	2			2				2	
U.S. reserve inadequacy, by 2015	3	4		2	4	2	3	4		2	4	1	2	4		
U.S. productive capacity inadequacy (mine or well)	4	4	1	2	4		3	3	1	1	4	2	1	4	2	
U.S. productive capacity inadequacy (smelter or processing plant)	2		1		2		3		1	1		2	1	1	1	2
Significant energy use	4				2	3			2			3		2	1	
Inadequate recycling			2	2	2	2	2	2	2			2		2	2	
Inadequate substitutes	3	4		1	4		3		1	1	3	1	3		3	2
U.S. foreign exchange drain	4				1				2	2		3				
U.S. vulnerability to foreign disruptions	3	3			4		4	2			3	2				

Table 4.6 (continued)

	Mica	Molybdenum	Nickel	Phosphates	Platinum Group Sand and Gravel	Silver	Strontium	Tellurium	Tin	Tin (Rutile)	Tungsten	Vanadium	Zinc	Zirconium
World resource inadequacy, by 2015						2								
U.S. high-grade resource inadequacy, by 2015	3		4		4	4		4	4	4	2	4	4	
U.S. low-grade resource inadequacy, by 2015	2			2					3					
231 U.S. reserve inadequacy, by 2015	3		4		4	2			4	4	2	2	2	
U.S. productive capacity inadequacy (mine or well)	2		4			2	2			4	3		2	
U.S. productive capacity inadequacy (smelter or processing plant)			3			2					1		2	2
Significant energy use														
Inadequate recycling		2	2						2		2		2	3
Inadequate substitutes	2	2	2		3	1	2	2	1	1	2	1	2	2
U.S. foreign exchange drain			2		2	2			2	1			2	
U.S. vulnerability to foreign disruptions			2		4	2	3		2	3			2	

Adapted from Morgan, 1977, p. 17, also references 20, 21 and 22.

To increase the estimated total petroleum resources, it will be necessary to find a completely new source region for petroleum. Two areas that have been proposed are the deeper portions of the earth's crust and the ocean bottoms. The first is very improbable as commercial quantities of crude oil do not occur at depths greater than 20,000 feet due to the temperatures and pressures associated with such depths (ref. 11).

The second, the ocean bottoms (not including the ocean's shelves and slopes), is more likely because the seabed has yet to be adequately explored geologically. However, there is the problem of developing the technology and industrial means to exploit petroleum which is beneath an average of 15,000 feet of water.

If new deposits are found, the very long lead times required to develop wholly new petroleum reserves requires that planning be done now (ref. 12, 13, and 14). Even longer lead times are needed to plan, finance, and conduct research into new and improved methods of seeking the hard-to-find deposits of hydrocarbons that will be needed by future generations.

It is also very unlikely that new deposits will increase our overall petroleum resources greatly because a very large percentage of the total petroleum found is a very small percentage of all known accumulations. More than 85 percent of the world's hydrocarbon production plus reserves occur in less than 5 percent (238 fields) of all producing accumulations. Even more remarkable, 64 percent of the hydrocarbons (petroleum and gas) occurs in slightly over 1 percent of all fields -- the 55 "supergiants" (a billion barrels more)(ref. 15) (Table 4.7).

Approximately 60 percent of all petroleum found outside communist countries is located in an area some 800 by 500 miles in the Middle East. The likelihood that such a prolific oil-bearing region will be found again appears small. Future additions to reserves are more likely to be obtained by improved recovery techniques. The percentage of oil that can be recovered varies from field to field (10 to 80 percent) but the general average is 30 to 50 percent. Recovery rates will improve gradually; starting small but increasing over the next 25 years.

With limited supplies of petroleum being a reality, we must realize it is essential that we determine when the change from a petroleum based economy will occur. This necessitates an understanding of how to determine the quantity to be used and how fast this use will occur. There are seven basic factors that interrelate to answer this question:

- | | |
|-----------------------------|-----------------------------|
| 1. World energy price | 5. Production limits |
| 2. World economic growth | 6. World demand |
| 3. National policy response | 7. Type of replacement fuel |
| 4. Petroleum discoveries | |

Using the above factors, several studies have tried to predict the future of petroleum. Hafele and Sassini (ref. 16) compared a projected population growth rate to world per capita energy use and determined that all oil and coal

Table 4.7

APPROXIMATE SIZE OF WORLD OIL FIELDS

	Number of Fields Discovered	Estimated % of Non- Communist World's Reserves
All fields	30,000	100
Fields greater than 0.5 billion bbl recoverable reserves	240	73
Fields greater than 10.0 billion bbl recoverable reserves	15	34
Four largest fields ^a	4	21

^aGhawar (Saudi Arabia), Greater Burgan (Kuwait), Bolivar Coastal (Venezuela), and Safaniya-Khafji (Saudi Arabia/Neutral Zone). Source: Martin, 1977, p. 40 (ref. 23).

would be used up between 2030 and 2064 assuming these two energy sources were all that were used and a 5KW/capita energy usage occurred. Allen (ref. 17) assumed that there are 2100 billion barrels of natural crude oil left. He determined that (1) at present world consumption rates, oil will last until 2054, (2) continuing present day growth at 5 percent, oil will last until 2004, and (3) if growth declines to zero by 2000, oil could last until 2023. Martin (ref. 23) determined that the end of the growth era in oil production is probably no more than 15 years away. Potential oil demand in the year 2000 is unlikely to be satisfied by crude oil production from conventional sources (Fig. 4.6).

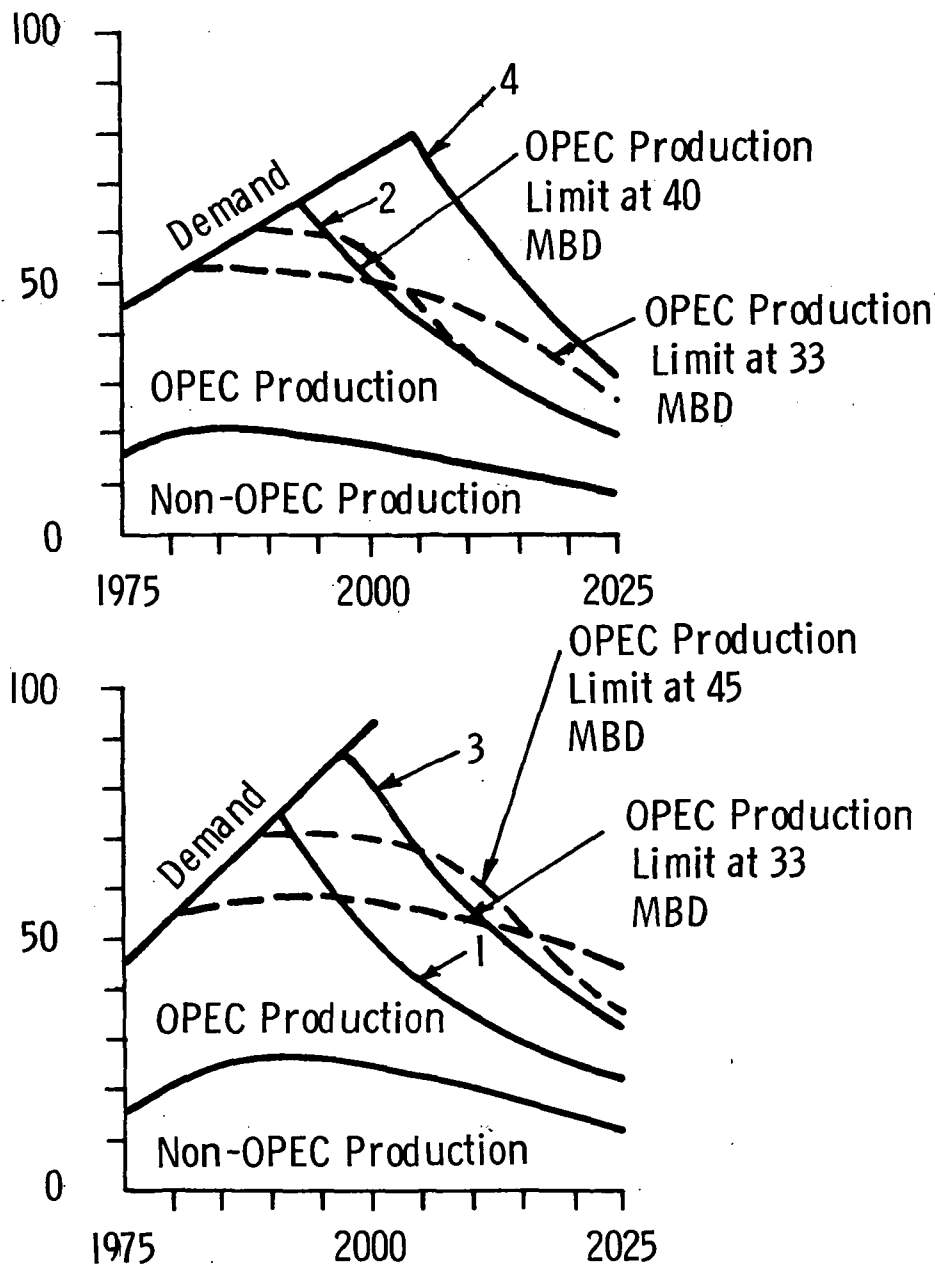
It is imperative that the world prepare to adjust to a declining oil supply in the near term (1990-1995). "There may be additional major oil discoveries or much higher recovery factors than have been assumed, but such favorable developments would only delay, not remove, the problem. Nations that continue to increase their oil consumption in the hope that more optimistic estimates will prove correct risk losing time to adjust their energy consumption patterns if their optimistic expectations are not met." (ref. 10)

From the above data, one definite conclusion can be made: potential oil demand in the year 2015 is unlikely to be satisfied by crude oil production from conventional sources.

4.2.2.2. United States Petroleum

At present, the most serious problem confronting the U.S. is for the American public to realize the seriousness of the energy crisis. Since the energy address by President Carter in the spring of 1977, the public has been made aware of the problem. However, the President has not been able to mobilize public opinion quickly enough. The country has not reached a consensus on energy policy. Perhaps this is due to the way Americans tend to deal with an unexpected national problem (1) be skeptical of the problem's existence, (2) search for scapegoats, and (3) settle down to dealing with the problem. The previous section indicated that the world is rapidly approaching a petroleum supply problem. Is the United States? The 6 percent of the world's population that lives in the U.S. consumes 31 percent of the world energy production. Energy consumption in the U.S. has more than doubled in the past 25 years, from 34 quadrillion BTU's in 1950 to about 78 quadrillion BTU's in 1975. This increase is equivalent to an average per annum growth rate of 4 percent. Projections of the total energy demand (ref. 18) to 2000 vary considerably and range from 124 quadrillion BTU to 192 quadrillion BTU.

Forty-five percent of the U.S. energy demand is supplied by petroleum. Although Hendricks (ref. 19) has estimated that 400 billion barrels would be ultimately recovered, all other estimates are near 150 billion barrels. In a series of papers, Hubbert (refs. 20, 21, 22, and 36) "concluded that the amount of ultimately recoverable petroleum in the United States is between 150 billion barrels for the contiguous states and about 200 billion barrels for the entire continental United States (including Alaska and the outer continental shelves). Hubbert's method is one of integral logistic curve fitting. It is related only statistically to rocks and geologic parameters, and to those only



1--2 No OPEC Production Limit, assuming 20 BB/Yr. additions to reserves to 2000, declining to 4BB/Yr. by 2025

3--4 No OPEC Production Limit, assuming 10BB/Yr. additions to reserves to 2000, declining to 4BB/Yr. by 2025
3BB/Yr. by 2025

Figure 4.6 TWO OIL PRODUCTION PREDICTIONS (Source: Martin, 1977, p. 15, (Ref. 23).

through a variety of economic and technologic factors. Supposing that human beings will be doing in the future as they have in the past, so far as petroleum exploration is concerned both technologically and from an investment viewpoint, Hubbert's approach is unassailable." (ref. 15)

At the present time, about 100 billion barrels have been produced in the U.S. The U.S. has consumed between 25 and 40 percent of its own petroleum to this date. By the year 2015 between 80 and 90 percent will be consumed.

This decrease in availability of U.S. produced petroleum will have several effects: production will drop from 8 to 12 million barrels daily in 1985 to 6 to 10 million barrels daily in 2000 (ref. 10), the U.S. will become more and more an energy-deficient country, the possibility of restrictions and threatened restrictions on U.S. oil imports will increase, decrease the independence of U.S. foreign policy, and bring havoc to the complex of both international and domestic economic matters.

In 1960, the net rate of external dependence on foreign oil stood at 5 percent, in 1974 it was 16.3 percent, during the first half of 1978 it varied from 40 to 50 percent. The possibility that it could reach 70 percent by 1990 is very real. This would be equivalent to an annual deficit of some \$50 billion in 1974 dollars.

It is the last figure which is the most important. Although the vulnerable nature of our energy dependence was made abundantly clear during the OPEC oil embargo, it is unlikely that the U.S. will be cut off from imported oil in the near future. But even if foreign imports are fairly assured for the near future, the balance-of-trade deficit is leading us into serious economic problems. We cannot long tolerate paying over \$30 billion annually for imported oil that cost only \$3 billion a year as recently as 1972.

In the next several years, the United States must develop a sound energy policy which includes the following parts: (1) rapidly increase the domestic energy supplies, (2) reduce demand by conserving energy, (3) develop new technologies through a massive new research and development program, and (4) aim for a lower energy future.

It would cost us little to direct the U.S. toward a low energy future and there would be major gains as to the possibility of achieving such an energy demand; a lowering of environmental and human damage, a lower risk of catastrophic accidents, and a strengthening of our economy.

4.2.2.3. Transportation -- Aviation

Primary energy consumption in the U.S. is almost evenly divided between residential, industrial, electrical, and the transportation sectors. Within the transportation sector, highway modes (bus, trucks, and autos) account for most of the energy consumed (Fig. 4.7.).

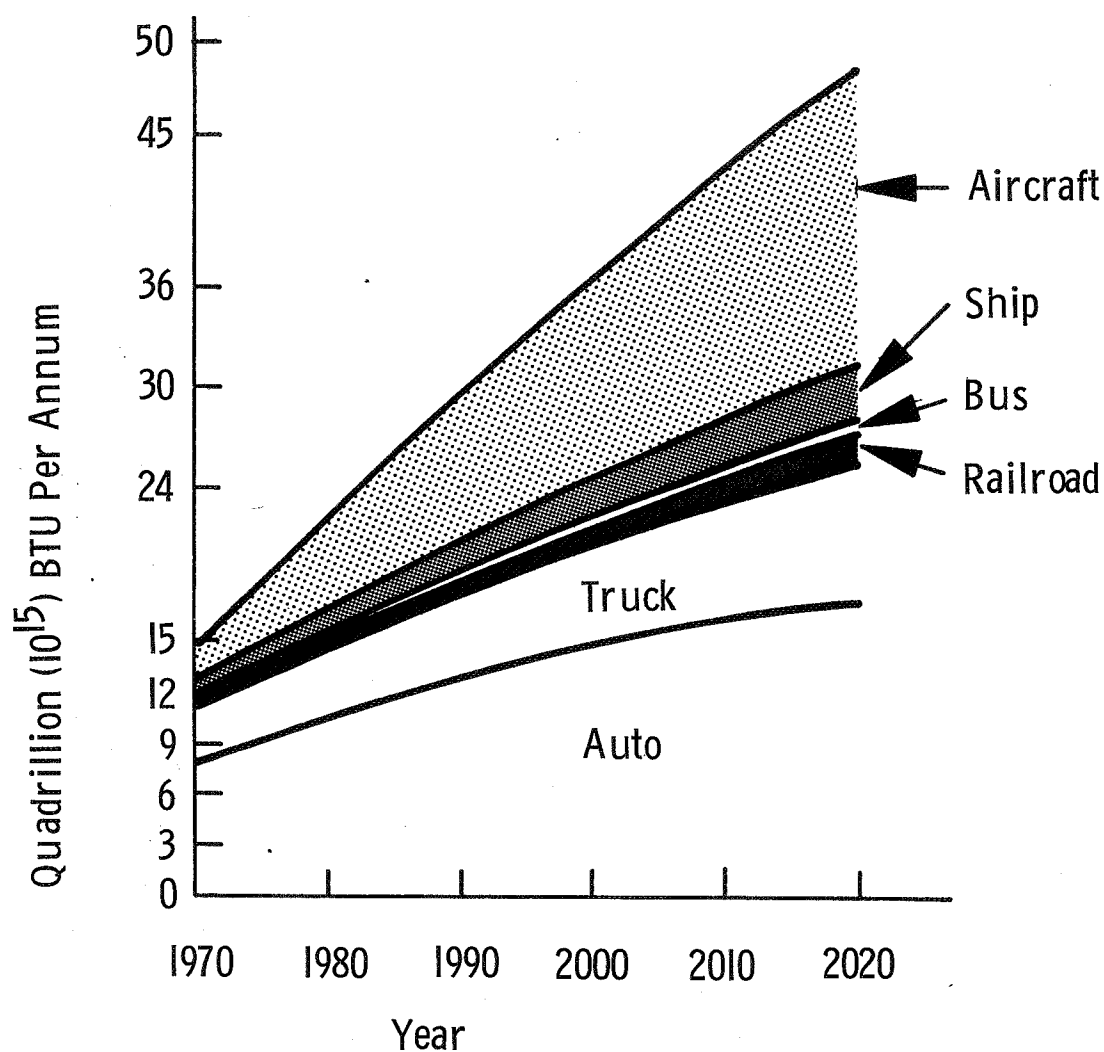


Figure 4.7 GENERALIZED ANNUAL TRANSPORTATION ENERGY CONSUMPTION
 Adapted from: Macrakis, 1974 (Ref. 37) (Sources:
 Duppee and West, 1972 (Ref. 38); Dyer, et. al., 1973
 (Ref. 39); Rice, 1970 (Ref. 40); Macrakis, 1974
 (Ref. 37).

In the U.S., transportation accounts for about one-fourth of the total energy used and about half of the petroleum consumption. The energy consumed by aviation, which accounted for only a few percent of the transportation energy consumption in 1960, amounts to about 13 percent of the transportation energy usage (about 9 percent civil and 5 percent military) or less than 4 percent of the total U.S. energy consumption. Although air transportation accounts for a small fraction of the U.S. petroleum used, aviation in all forms (passenger, freight, general aviation, and military aviation) is 100 percent dependent on petroleum fuels and strongly influenced by the availability and cost of these fuels.

Aviation is growing at a faster rate than all other transportation modes with energy consumption having increased at a rate of about 11 percent per year between 1963 and 1973. Although there was a decrease in fuel use from 1974 to 1976 (6 percent), a continuing increase of 4 percent (Fig.4.5) for the air mode is very possible. If this growth rate continues to 2000, aviation will change from its present relatively modest role into the dominant factor in future transportation energy consumption. Projections of aviation growth vary from 2 to 6 times. But, whatever that growth rate in aviation, it will consume a much larger fraction of the transportation sector's fuel in the future (Fig. 4.7).

The growth in the all air-cargo fuel consumption is also expected to increase drastically in the future. At a 5.8 percent annual growth, it would increase from 680 million gallons in 1974 to between 6 and 7 billion gallons by 2015.

4.2.2.3.1. Aviation Fuel Problems

As the aviation fuel need increases and the amount of crude oil decreases, several problems will arise. One is the conflict which will occur between transportation sectors because of differing fuel-requirements. If pressure from either the motor gasoline, petrochemical or high quality gas/oil markets reduces the volume of jet fuel below demand, Jet B could substitute. However, increased demand for naphtha and motor gasolines could, as in the past, reduce Jet B's availability. There is also the possibility that a new need for the jet fuel fraction of crude oil could develop and cause aviation fuel shortages.

Another problem is the amount of direct operating cost (DOC) that is caused by fuel acquisition. The ratio of fuel costs to the total cost of air transportation has been relatively low for most of aviation's history. However, since the Middle East War of 1973 and its related embargo and fuel price increase, the price of fuel has become the single most important item in DOC.

It is this high fuel contribution to DOC that has brought about the situation whereby, at the current level of U.S. airline fuel use of 10×10^9 gals/yr (CAB data), each cent/gal increase in the price of fuel costs the airlines 100×10^6 dollars.

Of course, it is the increase in the price of fuel which is causing the DOC fuel problem. Air Transportation Association data indicate that the cost

of fuel climbed from \$1.4 billion in 1973 to \$2.3 billion in 1974 even though consumption was cut from 10.7 billion gallons to 9.6 billion gallons. Fuel prices will apparently continue to increase for the indeterminate future because of the inflationary spiral that has been generated. Fuel price increases join with other inflationary forces to drive up the prices of the things the oil-producing countries buy. This leads to further increases in what they charge for fuel. This increase will intensify as the necessity of exploiting new, more capital and energy-intensive fossil-fuel and raw materials sources increases.

This fuel cost problem will not be as serious for air cargo as for the passenger portion of aviation for if a ticket of a passenger increases from \$300 to \$400, there is certainly a chance of a decreased passenger demand. However, if the air-cargo rate goes from 30 cents a pound to 40 cents, the ten-cent increment can be readily passed on to the consumer as a 1 or 2 percent increase in the retail price of the goods. In summary from the energy point of view, aviation has to face in the short term much higher fuel costs with supplies critically dependent on political stability and in the long term steadily increasing fuel costs with no satisfactory alternative fuel yet in prospect.

4.2.3.3.2. Ways to Improve Fuel Utilization

The air transportation system, both in operation and equipment, has never been designed for minimum fuel utilization. Even so, the fuel efficiency of aircraft has improved from 1920 to 1975 by a factor of four. Using the value of 1920 as a constant base, this represents an average increase of about 5 percent per annum. From 1955 to 1975, the jet era, this rate of improvement has corresponded to a rate of 10 percent per annum. Now fuel efficiency is clearly the prime target for designers who, by technological advance, can directly influence the economic effectiveness of much of the research and development in the aerospace industry.

The rising energy consumption for all transportation, the increasing dependence of transportation on petroleum, the growing level of petroleum imports, the impending shortage of adequate oil supplies, and the rising price of fuel make the need for significant increases in aircraft fuel efficiencies mandatory. There must be no delay in developing advanced technologies to provide compensating improvements in fuel consumption. Sufficient research must be done to accommodate the use of alternative fuels should the need arise. While it may be hoped that economies in other energy areas will leave sufficient petroleum for the relatively small requirements of aviation, it is unacceptably risky to rely on such hopes. The airlines were the first, not the last, to have fuel allocations imposed in the fuel crisis of 1973-1974. A number of studies (refs. 24, 25, 26, and 27) have recently been made in response to the concern of the impact of the energy crisis on commercial aviation. These studies indicate that although current transport aircraft are reasonably energy-efficient, considerable improvements can be made in future aircraft designs through incorporation of advanced technology.

In addition to the technological advancements that can improve fuel efficiency, other direct and indirect energy requirements must be investigated. These other energy requirements include the energy expended in switching and repositioning equipment; regular maintenance; storage; training; extra operations because of adverse weather; equipment breakdowns; extraordinary traffic delays; heating, cooling, and lighting of offices and terminals; advertising displays; energy expended in producing, refining, and distributing the fuel; and the indirect energy consumed in constructing and manufacturing the various facilities, structures, and equipment associated with a particular transportation system.

Fuel efficiency improvements in some of the above areas were responsible for a 7.5 percent fuel consumption decrease during the 1973 to 1976 period even though the overall passengers carried increased by 10.4 percent.

A listing of possible methods to increase fuel efficiency appears below. It is divided into management and maintenance, aircraft technology, and operational procedures (aircraft flight operations and aircraft ground handling).

Methods to Increase Fuel Efficiency

I. Management and Maintenance

- Retirement of older inefficient airplanes
- Drag reduction maintenance
- Reduced training flights (use of simulators)
- Increased seating and payloads
- Rely on energy-economical concepts where possible (ex: lighter-than-air heavy cargo lifting)
- Higher density seating (increased capacity)
- Higher load factors
- Fleet mix and usage
- Airport design

II. Aircraft Technology

- Advanced airfoil design - new supercritical wing, improved aerodynamic fairings
- Increased aspect ratio - stretched fuselage
- Lowered structural weight by less swept, thicker wing
- Use of composite materials - fairings, wing and tail extensions, floor, doors
- Fuel conservative engines (optimum design parameters between engine specific fuel consumption and aircraft design efficiency parameter)
- Active controls to reduce size, weight, and drag of surfaces
- Laminar flow by boundary layer control
- Re-introduction of turbofan where possible
- Alternative fuels utilization and the engines that can use them (this would act to decrease dependency on petroleum-derived fuels)
- Wing tip vortex dissipation

III. Operational Procedures

A. Aircraft Flight Operations

- Climb to cruise altitude as fast as possible
- Select fuel efficient cruise altitude
- Use fuel efficient speed enroute
- Hold to cruise altitude as long as possible
- Use fuel efficient descent profile and if possible idle some engines
- Use minimum circuitry in departure and approach patterns
- Reduced air traffic control delays
- Routine monitoring of flight fuel consumptions and operating procedures
- All weather operations

B. Aircraft Ground Handling

- Reduce engine usage in taxiing in
- Take delays at gate with engines off
- Delay start up of engines until pushoff
- Reduce engine operation in taxiing out
- Increase use of towing
- Manage better all the terminal operations
- Better diagnostic procedures of engine problems and use of materials that resist deterioration
- Control of fuel reserves and dumping

The above information was compiled from sources in references 25, 27, 28, 29, 50 and 51.

Once the operational and management improvements are implemented, the reduction of aircraft fuel consumption will occur by employing advanced technology to improve the efficiency of the vehicle and the propulsion systems. Figure 4.8 illustrates some of these improvements interrelated to the percent of fuel utilization improvement and the years of introduction. When advanced engine and materials as well as the laminar flow control are available, the possibility of a completely new fuel efficient plane will increase. This may also be when alternative fuels will become the major source of aircraft fuels.

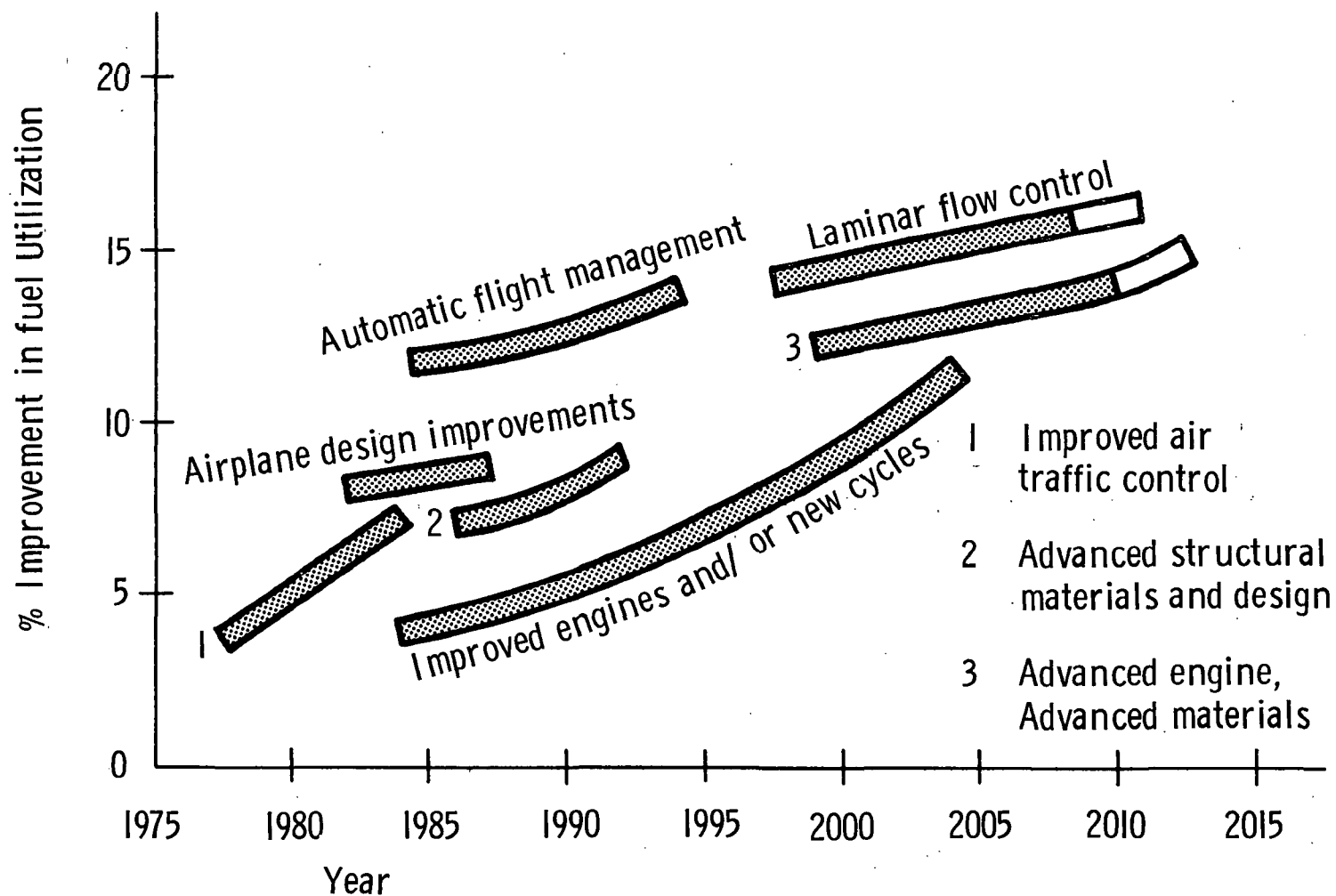


Figure 4.8 THE PERCENT OF FUEL UTILIZATION IMPROVEMENT RELATED TO THE YEARS OF INTRODUCTION

4.3 PUBLIC POLICY, ACIS AND FUELS

There are three special areas where public policy makers should direct their attention with respect to the ACIS. These areas are: (1) the design of a fuel efficient intermediate size aircraft; (2) allocation of fuel to ACIS in the event of a critical fuel shortage; and (3) the development of alternative fuels.

4.3.1. Fuel Efficient Aircraft

A fuel efficient intermediate size aircraft is needed. This plane should be designed to accept standard size containers, use composites wherever possible, and have a fuel efficient engine; possibly a new type of turboprop which is highly loaded, multibladed, and has advanced blade structure.

The above described aircraft is needed now, but because of the serious economic problems of all segments of the U.S. including the airline and aircraft industries, it is not presently being given the attention required for implementation. In the very near future, 1980-1985, this attitude must change. ". . . there should certainly be a heightened emphasis on research and development work related to future potential aircraft systems, with emphasis on improved efficiency at reduced cost. Whether derivatives or new systems prevail, only through aggressive and dedicated research and development efforts can the many potential improvements in fuel conservation, other operational cost factors, and production costs be brought to fruition. All of the technological potentials discussed earlier, and many more, need to be developed further. It is through this entire mechanism, of course, that one should reasonably expect to discover one or more "breakthroughs," which will be the means of a shift from our current technology curve to another more beneficial level, thus alleviating the adverse cost impact factors now faced by all new cargo systems. When one reflects that it has been only a little over 20 years since the first service of a British commercial jet-propelled passenger airplane and less than 17 years since the first commercial service of a U.S. jet, the supposition that a few more years might have to pass before a significant breakthrough may be made with new advanced cargo aircraft should cause no great disappointment." (ref. 30)

4.3.2. Fuel Allocation in Case of Shortage

The OPEC oil embargo of 1973 drove home the dependence of the U.S. economy on imported petroleum. As has been previously presented, this dependence has increased since 1973. At the time of the embargo, the federal government limited sales of automobile gasolines; however, the only public mode of transportation to be allocated reduced fuel supplies was the commercial airlines. Why was this done? The scheduled domestic airlines consumed less than 5 percent of refinery output and it is very likely that the traffic shifts from automobiles increased the public demand for air service. If the same situation

happened now would the same result occur? Very likely. Jet aircraft are very visible consumers of energy and their "high" fuel consumption is the subject of much discussion.

If the ACIS is allowed to come into being, policy planners must safeguard against any shortsighted response which could be far more destructive for a highly integrated air cargo system than would be the case for passenger systems. In the first place, our system is characterized by low connectivity; a drastic cutback in fuel might, therefore, render the system totally inoperative. In the second place, we recommend vertical integration of cargo carrying modes. Thus, a disruption of one element of the system might render a much larger system inoperative. In the third place, the kinds of saving we expect shippers to realize, when using air rather than truck, depend largely upon their being able to lower inventories. Thus the users of air cargo will become extremely vulnerable to any stoppage in the movement of their goods. It is probably impossible to even begin to calculate the amounts and kinds of economic damage that might occur if, after allowing the ACIS to be put into place, we then permit the capricious disruption of the system. For, although it is true that only a small part of all goods shipped will move by air, those goods that are shipped by the ACIS will be essential to the utilization of things moved by other modes. Therefore, whole industries might fail to function if ACIS fails to function.

As has been mentioned before, the air transportation demand for fuel has grown from a few percent of all transportation energy consumed in 1960 to about 13 percent today. Of course, this growth calls attention to aviation's demands on a petroleum supply which is being depleted; however, air transport has demonstrated a continued history of improved energy efficiency. To give perspective, when the 1976 demand for major petroleum products is compared with the 1970 demand, the airlines have stabilized but other petroleum product consumers have demanded large increases: 19.5 percent for motor gasoline, 23.2 percent for distillates, and 26.4 percent for residual fuel oil. These "increases are the major cause of the continued rise in the nation's petroleum consumption and a cause of the accelerating import problem. Indeed, the increase in gasoline consumption from 1970 to 1976 exceeds the total jet fuel consumed by all aviation in 1976." (ref. 31)

There are two other major factors which strengthens the airlines case for the right to fuel: (1) The increased opportunity and productivity of passengers because of the speed of aircraft which also allows a greater radius of communication and travel. This benefits the nations economy. (2) A healthy airline industry assists the foreign trade balance of payments. Exports of commercial air transports and associated equipment generate approximately \$3 billion each year. Airline competition has fostered a manufacturing industry whose products dominate world air transportation.

We believe that from a cost/benefit viewpoint, aviation is vital to our nation. Aviation provides vital services and capabilities that cannot be achieved in any other way. Aviation is not grossly consumptive of energy and airplanes of the future will be able to compete very favorably with other forms of transportation on an energy basis. "Adequate air transportation

today is not merely a convenience but a vital resource that cannot be given up without major changes in lifestyles, business procedures and productivity in government, industry, and private affairs" (ref. 25) The airlines provide a service that is not duplicated by the other transportation modes. In future restricted import situations, federal policy should be founded on a well researched understanding of the needs and alternatives for all users rather than a reactive solution based on the strength of political lobbies.

4.3.3. Alternative Fuels

Even if the aircraft industry is exceptionally successful in succeeding to develop and implement all the fuel efficient programs listed previously. They may still experience long-term difficulties in meeting jet fuel requirements from domestic and imported petroleum supplies. Not only is there an increasing demand for the crude oil fraction that can be made into jet fuel, there is a definite limit to the crude oil supply.

Therefore, it is assumed that in the early twenty-first century some supplementary alternative fuels will be developed. A tremendous amount of effort has been expended on trying to determine the actual alternative fuel to be developed (refs. 17, 27, 32, 33, and 4). Because they must be readily available, at a realistic price, compatible with existing aircraft and ground facilities, and not disturb operational or other characteristics of the aircraft used, it is believed they will be much like those in use today and will be produced by utilizing coal and possibly oil shale as the basic source (refs. 35, 36, 37, and 38). There is also a chance that more unusual fuels, such as methanol, methane, hydrogen, and even nuclear, may be used (refs. 39, 40, 41, 42, 43, and 44).

4.4 GOVERNMENT ROLE AND MARKET FORCES

4.4.1. The Role of Transportation in the U.S. Economy

Because of the vital role of transportation in the life of the nation, federal, state, and local governments have, in the past, participated in its promotion, planning, and support. The U.S. has provided subsidies and aids to various transportation modes in promoting commerce, the Postal Service, national defense, and international trade. Transportation even in a capitalist or market system, such as the U.S. is rarely left completely to the market. Accordingly, it has been a mixed system of private and public enterprise.

The federal government has played a very important role in the development of air transport. For example, from 1919 to 1923, the Post Office Department experimented with mail transportation. After 1925, the Department of Commerce took over the task of developing a system of civil airways and aids to navigation. The federal government has also provided and operated the airways, air navigation facilities, and air traffic control through the Federal Aviation Administration. Local governments have also been involved in the development, operation, and support of airports.

The promotion of the ACIS is also an important factor in employment. According to the U.S. Department of Labor, transportation's share in total national employment will drop from 4.5 percent in 1968 to 2.8 percent by 1985, but the proportion of civil aviation workers in the transportation labor field should increase from 14 percent in 1968 to 28 percent by 1985 (ref. 45). An ACIS could also beneficially affect gross national product and tax receipts.

4.4.2. Improvement of the Balance of Trade

The aerospace industry also plays a very important role in the U.S. balance of trade. In 1977, while the U.S. suffered a trade balance deficit of \$29.113 billion, the aerospace industry had a trade balance surplus of \$6.850 billion. Aerospace industry exported \$7.581 billion and imported only \$731 million. Aerospace industry was second only to agriculture in favorable contribution to our balance of trade. Since World War II, the aerospace industry has contributed a great deal to the U.S. balance of trade (Table 4.8).

4.4.3. Government Role in the International Market Place

Before and during World War II, the U.S. conducted an aeronautical research and development program of extraordinary scale. In the post-war decade, U.S. aircraft builders further benefited from new technology made available by advancing research and development. Thus, the U.S. has continued its superiority in the aircraft industry, but whether we can maintain our superiority in the future is of great concern to many persons in this country.

Table 4.8

TOTAL AND AEROSPACE BALANCE OF TRADE
(Millions of Dollars)

Year	TOTAL U.S. Trade Balance	Aerospace			Aerospace Trade Balance as Percent of U.S. Total
		Trade Balance	Exports	Imports	
1960	\$ 5,369	\$ 1,665	\$ 1,726	\$ 61	31.0%
1961	6,096	1,501	1,653	152	24.6
1962	4,180	1,795	1,923	128	42.9
1963	6,061	1,532	1,627	95	25.3
1964	7,555	1,518	1,606	90	20.1
1965	5,875	1,459	1,618	159	24.8
1966	4,524	1,370	1,673	303	30.3
1967	4,409	1,961	2,248	287	44.5
1968	1,133	2,661	2,994	333	234.9
1969	1,599	2,831	3,138	307	177.0
1970	2,834	3,097	3,405	308	109.3
1971	-2,024	3,830	4,203	373	
1972	-6,351	3,230	3,795	565	
1973	1,222	4,360	5,142	782	356.8
1974	-2,996	6,350	7,095	745	
1975	9,625	7,045	7,792	747	73.2
1976	-7,803	7,267	7,843	576	
1977	-29,113	6,850	7,581	731	

Since the 1960's due to the Vietnam War, high rates of inflation and a general decline in national economic health, federally funded research and development in the United States has declined. In the meantime, the governments of Western Europe and Japan have provided strong financial support to their aircraft industry in the area of research and development. The growth rate in aerospace research and development for the Common Market countries has averaged 15 percent annually, compared with 6 percent for the United States.

European governments are promoting the consortium approach to aircraft development. For examples of such collaborative efforts, see Table 4.9. Cooperation among nations makes it possible to undertake programs that would otherwise be impossible for an individual country. The consortium approach makes it possible to utilize economic resources of the cooperating nations in the most efficient way for research, development, testing, and production. It also allows nations to take advantage of economics of scale in production because of internal market size. The Western European countries, taken together now constitute a market equal to that of the United States. A cooperative approach fosters development of a wider range of aircraft types because of the broader market and differing kinds of service provided by the airlines of the cooperating nations (ref.42). Thus the consortium approach provides a potentially strong competitive challenge to American industry.

In order to improve the state of the aircraft manufacturing industry and to compete with foreign countries, it is essential for this country to have healthy airlines. A study of the ownership of airlines reveals that all major foreign international airlines except CP Air are wholly or partially owned by their governments (Table 4.9). Foreign governments are also involved in the operations of the airlines and this enables foreign airlines to capture a greater share of the international market. NASA Cargo/Logistics Airlift System Study (CLASS) completed in June 1978 by the McDonnell-Douglas Corporation predicted that market growth between 1978-1990 for U.S. international airlines will increase by 8.3% annually whereas foreign airlines will increase by 14.3%.

In the face of increased European national and multinational financial involvement in the development of advanced technology, the production of aircraft, and the operations of airlines, it is essential for the U.S. government, not only to be involved in the development of the advanced air cargo system, but also in the development of future cargo aircraft.

4.4.4. Capital Formation and Government Role

According to the Air Transport Association of America, the airlines will need about \$60 billion for the ten year period, 1980-1990 (ref. 47). Industry leaders and stockbrokers feel this amount can be raised in the absence of deregulation, with only minor difficulties experienced by a few carriers. The capital requirements after 1990 will depend upon the needs of new aircraft and the investment in ground support. Because the investment in ground support, such as terminals and equipment, is approximately 10 percent of the cost of the planes, the major capital requirements for the near future will be for aircraft. The airlines and aircraft manufacturers are the principal portion

of the aircraft industry that require capital.

4.4.4.1. Carrier

There are five principal sources of funds for transportation carriers: debt financing, equity financing, retained earnings, the government and manufacturers.

Historically the air transport industry has had a high level of financial leverage; a high debt-equity ratio. This is because of the heavy reliance on debt instruments to finance aircraft and equipment. Such financing occurs because the cost of debt financing is low relative to equity financing. In the early 1970s, debt-equity ratios peaked at 2:1 for the carriers as a group, and individually some crossed the line of 3:1. Because of regulation, lower levels of competitive risk and the assured nature of carrier route structures and fare levels, the air transport industry was able to support a high level of financial leverage. However, in a non-regulated market, financial institutions and investors will want to see the debt-equity ratio at a 1:1 ratio; so, carriers will have to undertake a combination of debt reduction and new equity financing. Deregulation and the new attitude of the CAB, which indicates it now will tolerate some carrier financial failure, at least for the short run, will cause financial institutions and investors to be reluctant to lend capital to already heavily-indebted airlines. However, some carriers, Delta and Northwest Orient for example, will still be able to borrow without much difficulty. Northwest's debt is small by trunk airline standards, and Delta, although it has gone deeper into debt, has nonetheless stayed below a 1:1 debt-equity ratio.

In the long run, economic deregulation will create a climate in which the industry will prosper, even though some specific carriers may not. A general increase in supply and capacity of the domestic air cargo industry can also be expected because of deregulation. The market will tend to create more premium services at higher prices in heavy traffic markets. The market forces will also permit the emergence of intermodal transportation companies. This means that some carriers will emerge as financially sound companies and will be able to generate enough capital through retained earnings and equity financing to purchase new aircraft. The successful sale of equity depends on investor confidence. If deregulation would make the air transport industry a growth industry again, carriers would be able to raise capital without too much difficulty.

4.4.4.2. Manufacturer

Developing a new aircraft calls for an enormous investment by the manufacturer. Costs have risen to the point where it takes more than one billion dollars to design and build an operational airplane. Figure 4.9 presents the financial history of the development program for a hypothetical new technology subsonic jet transport. In the first four years of development, the program would not reach the break-even point for about eight years or until after about 330 aircraft have been delivered (Fig. 4.9).

Table 4.9

GOVERNMENT OWNERSHIP:
24 FOREIGN AIRLINES, PAN AM AND TWA

<u>Airline</u>	<u>Ownership</u>
Aerlinte Eireann (Irish)	100 percent government owned.
Aeromexico	100 percent government owned since 1959 through Nacional Financiera S.A.
Air Canada	100 percent government owned through Canadian National Ry.
Air France	98.55 percent government owned.
Air India	100 percent government owned.
Air New Zealand	100 percent government owned.
Alitalia	75.5 percent government owned thru Instituto per la Reconstruzione industriale (IRI).
Argentine Airlines	100 percent government owned.
AyLANCA	Substantially owned and effectively controlled by Colombian government Pan Am owns 14 percent but exercises no management control.
British Airways	100 percent government owned.
CP Air	Privately owned by Canadian Pacific Ltd.
Et al	Government owned except for a few shares.
Iberia	Wholly government owned except for few shares, thru Instituto Nacional de Industria (INI).
Iran Air	100 government owned.
Japan Air Lines	45 percent government owned. Government effectively controls airline.

<u>Airline</u>	<u>Ownership</u>
KLM	70 percent government owned; government effectively controls KLM.
Lufthansa	Government and government institutions own 70.15 percent.
Pan Am	Privately owned.
Philippine Air	75 percent privately owned; quasi-government insurance corp. owns 25 percent.
Qantas	100 percent government owned.
Sabena	65 percent government owned; rest by individuals or in trust by government.
SAS	55 percent owned by governments of Denmark, Norway, Sweden; 45 percent by private investors.
Swissair	Government units and institutions own 23.6 percent
TWA	Privately owned.
Varig	96.11 percent privately owned, 3.89 percent by state government.
Viasa	Government of Venezuela holds 55 percent domestic airline Avensa owns rest.

Source: Aviation Economics, Joint Hearings Before the Subcommittee on Investigations and Review and the Subcommittee on Aviation on the Committee on Public Works and Transportation, House of Representatives 94th Congress March-April, 1976, Washington: U.S. Government Printing Office, pp. 24-31.

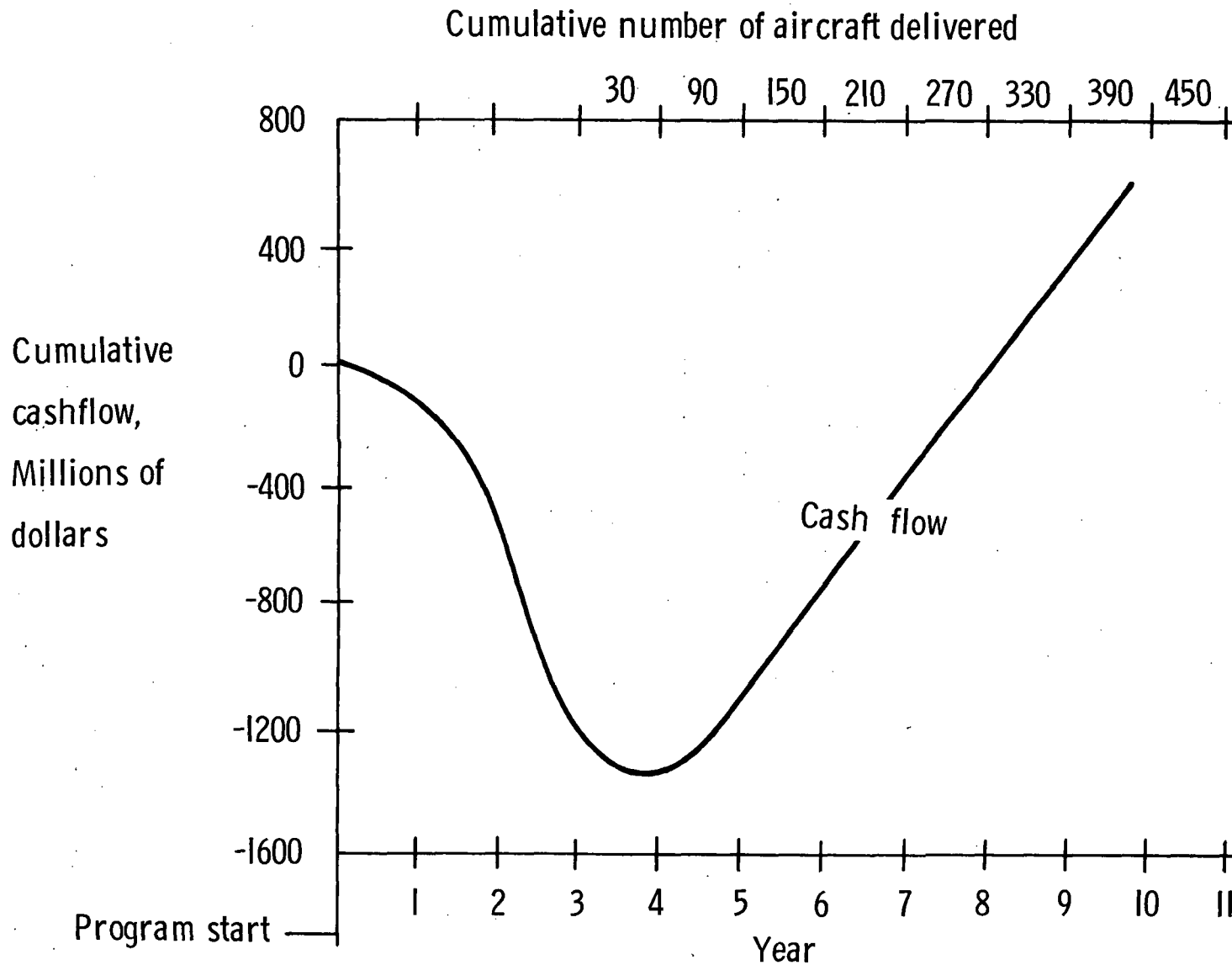


Figure 4.9 CASH REQUIREMENTS; LARGE COMMERCIAL AIRCRAFT PROGRAMS
PRIVATE FINANCING (Source: MIT-NASA Workshop Airline
Systems Analysis, Volume 2, July 1972, p. x-16).

The aircraft manufacturing industry has been and always will be dependent upon government for research and development. However, in the past, the American manufacturers have been able to finance their own commercial aircraft programs. It can be assumed that they will be able to continue to do so in the future. The financial positions of the manufacturers will allow them to undertake development of new commercial aircraft programs if the demands of a new aircraft justify the investment. Table 4.10 shows that the long-term debt for Boeing is comparatively limited and the company will be able to go to the market for borrowing. Boeing also has an unused line of credit. There will be other sources of money available to the company as well. McDonnell-Douglas has limited its long-term debt. The need for a U.S. Government guarantee has now been eliminated for Lockheed because of the improvement of its financial position. Boeing has managed to retain equity well in excess of issued stock value. McDonnell-Douglas has a smaller stock base, but its stockholders' equity is close to the Boeing figure. Lockheed, of course, needs much strengthening in its equity (Table 4.10).

Table 4.10 shows that the net profit after taxes, as a percent of sales for aerospace manufacturing corporations, has improved since the 1960s. If the demands of a new aircraft justify the investment, the capital can be provided by air transport carriers and manufacturers.

4.4.4.3. Government

In buying aircraft, the financial arrangement is a dominant factor. Foreign governments and foreign manufacturers are very much involved in the financial arrangements related to the sales of their airplanes. For example, Airbus Industrie came up with guaranteed financing for its \$778 million package sale to Eastern and Rolls-Royce Ltd., a British state-owned engine maker, offered to guarantee financing for Pan American World Airways to purchase airplanes equipped with Rolls Royce engines. Foreign manufacturers will have an obvious advantage over American manufacturers because the latter cannot offer guaranteed financing. By working with American manufacturers, the United States government can get involved in guaranteed financing to purchase American aircraft and help to offset the support that foreign industries are getting from their governments. This support is needed if the positive trade balance of the aerospace industry is to continue.

4.4.5. Conclusion

In the face of increased European consortium, nationalism, foreign government financial involvement in the development of advanced technology and production of aircrafts, and operations of airlines, it is essential for the U.S. government, not only to be involved in the development of the advanced air cargo system, but also in the development of future cargo aircraft. By 1980, the U.S. government should be involved in guaranteed financing to purchase aircraft in order to enable U.S. industries to compete effectively in world markets, and to maintain their superiority in air transport and aerospace industry. While the general philosophy of the United States has been to idealize competition in our domestic economy, we must reexamine the concept of "competition" in the light of foreign government involvement in international economy and global politics in 1990.

Table 4.10

U.S. AIRCRAFT MANUFACTURING COMPANY BALANCE SHEETS
(millions of dollars)

	Boeing	Lockheed	McDonnell Douglas
Fixed assets	400.7	256.1	249.6
Current assets	1,771.0	848.9	2,018.3
Current liabilities	1,029.9	780.5	1,332.2
Net current assets	741.1	68.4	686.1
Other assets	268.7	463.9	199.6
Capital employed	1,410.5	788.4	1,135.3
Long-term debt	104.1	536.0	79.5
Other liabilities	75.1	33.6	--
Net worth	1,231.3	218.8	1,055.8
Preferred stock	-	48.5	
Common Stock	553.9	11.4	38.4
Share premium	-	88.4	314.1
Retained earnings	684.0	70.5	721.1
Treasury stock	(6.6)	-	(17.8)
Shareholders equity	1,231.3	218.8	1,055.8
1977 SALES			
Aircraft	3,423	1,970	2,841
Spares and missiles	446	1,206	601
Other	208	197	163
Corporate income	47	-	-
TOTAL	4,124	3,373	3,605

Source: Flight International, June 10, 1978.

4.5 MILITARY AIR CARGO NEEDS AND DEFENSE POLICY

As American forces pull back from Europe and Asia, the demand on our strategic airlift capability increases. An advanced air cargo system is important to our national defense. Not only does the system serve the needs of our complex economy but at the same time it provides the military with a ready capability through CRAF (Civil Reserve Air Fleet) to meet our strategic needs. The post-Vietnam political environment has generated a number of perceptible trends in American society that are relevant here.

The critics of military spending have argued that the expansion of military budgets results in lower level of public expenditure on the development of social programs (ref. 49). As Figure 4.10 shows, the world's arms budget was almost double the public expenditure for health care in 1975. Such analyses have generally contributed to critical orientations toward military spending (ref.50).

In Western Europe, the younger generation has developed a negative attitude toward military expenditure. In the words of a member of the Western European elites, "There is growing up a generation which, mercifully, has had no firsthand experience of war and all that it means in terms of human misery and national disaster. This generation is now reaching the age where its members are becoming influential in politics, commerce, industry, and all aspects of life. It is therefore expected that its attitude toward defense expenditure, and indeed to military strategy, will be very different from those of the preceding generation, which has experienced two disastrous European wars (ref. 51).

In the United States, there are various sentiments toward the need to reduce military expenditures. At the height of the Vietnam war, as many as 52% of a national sample wanted to see reduction in military spending. These sentiments have recently waned and in 1977 the figure dropped to 23%.

Nevertheless, the American public does not seem highly supportive of overseas military involvement (ref. 52). As Table 4.11 shows, only a minority of the American public would recommend sending troops to foreign countries. There is significant variation, however, in this dimension of public opinion. Sending troops is recommended by 57% of the public if Canada is attacked, however it drops to 7% in the case of India and Saudi Arabia.

In recent years, the American military has been the subject of critical journalistic and scholarly writings (ref. 53). The military is perceived as just another interest group trying to get a slice of the budget pie (Fig. 4.11). Buzz phrases such as "military industrial complex" and "interservices rivalry" are expressions of critical attitudes toward military projects and its R & D requirements (ref. 54, 56). Arguments have been made in favor of more detailed scrutiny of military budgets by the Congress. However, growing awareness of the nature of government decision-making processes may have contributed to

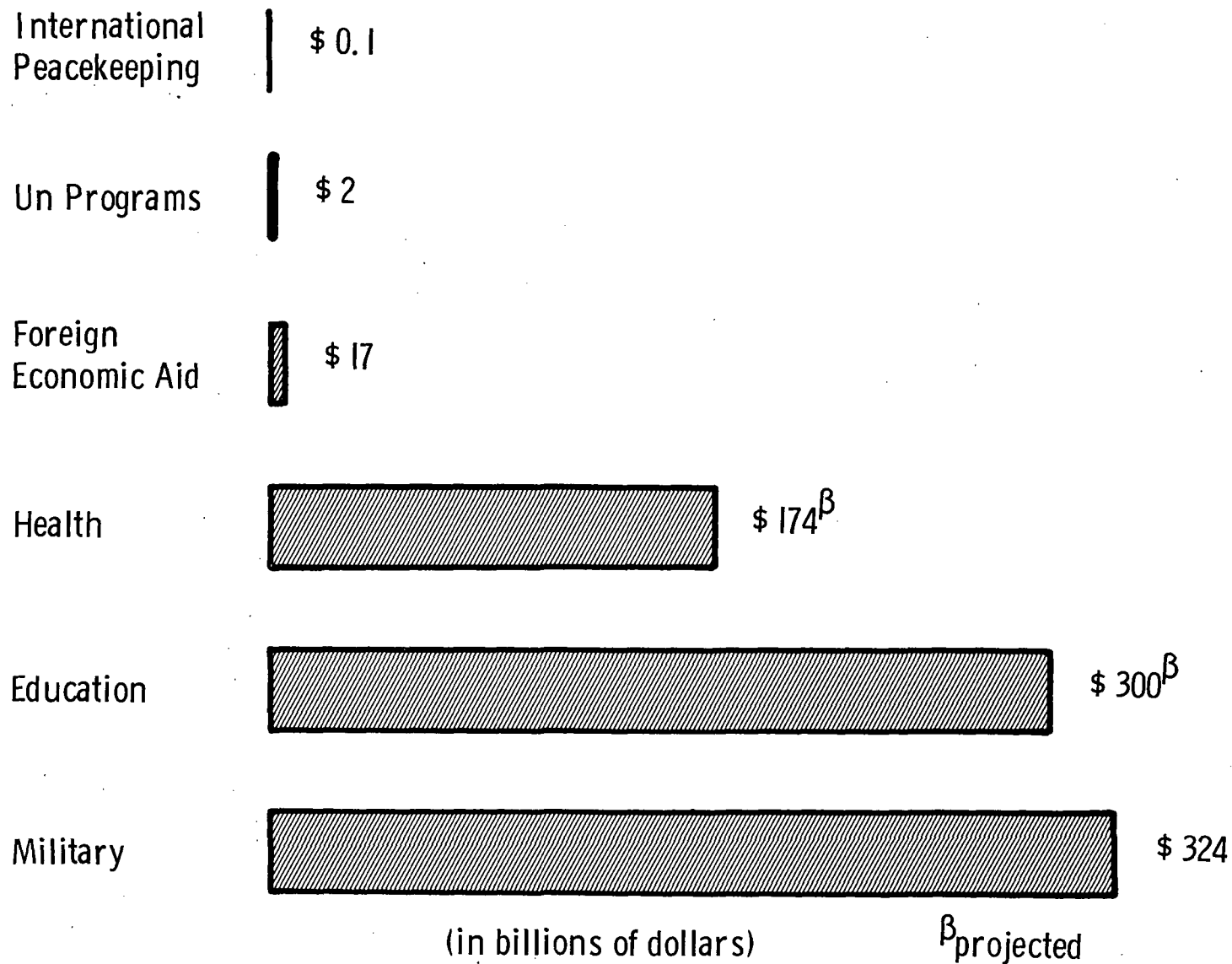


Figure 4.10: COMPARISON OF WORLD EXPENDITURES, 1975 (Source: Military Budgets and Social Needs: Setting World Priorities (New York: Public Arrairs Committee, 1977, p. 4).

Table 4.11

ORIENTATIONS OF AMERICAN PUBLIC TOWARD
U.S. MILITARY ASSISTANCE TO OTHER NATIONS*
(1975)

Selected Nations	Typologies of Public Response			
	Send Troops	Send Supplies	Do Not Involve	No Response
England	37%	30%	24%	9%
West Germany	27%	32%	33%	8%
Canada	57%	19%	14%	10%
Israel	12%	42%	37%	9%
Japan	16%	35%	40%	9%
Mexico	45%	26%	19%	10%
Brazil	16%	36%	33%	15%
Taiwan	8%	27%	54%	11%
Turkey	10%	36%	37%	17%
India	7%	40%	39%	14%
Philippines	29%	34%	26%	11%
Saudi	7%	27%	54%	12%

Source: Gallup Abstract, July, 1975.

* Percentage of national sample suggesting different types of military involvement overseas.

Orientations of the American public toward military expenditure

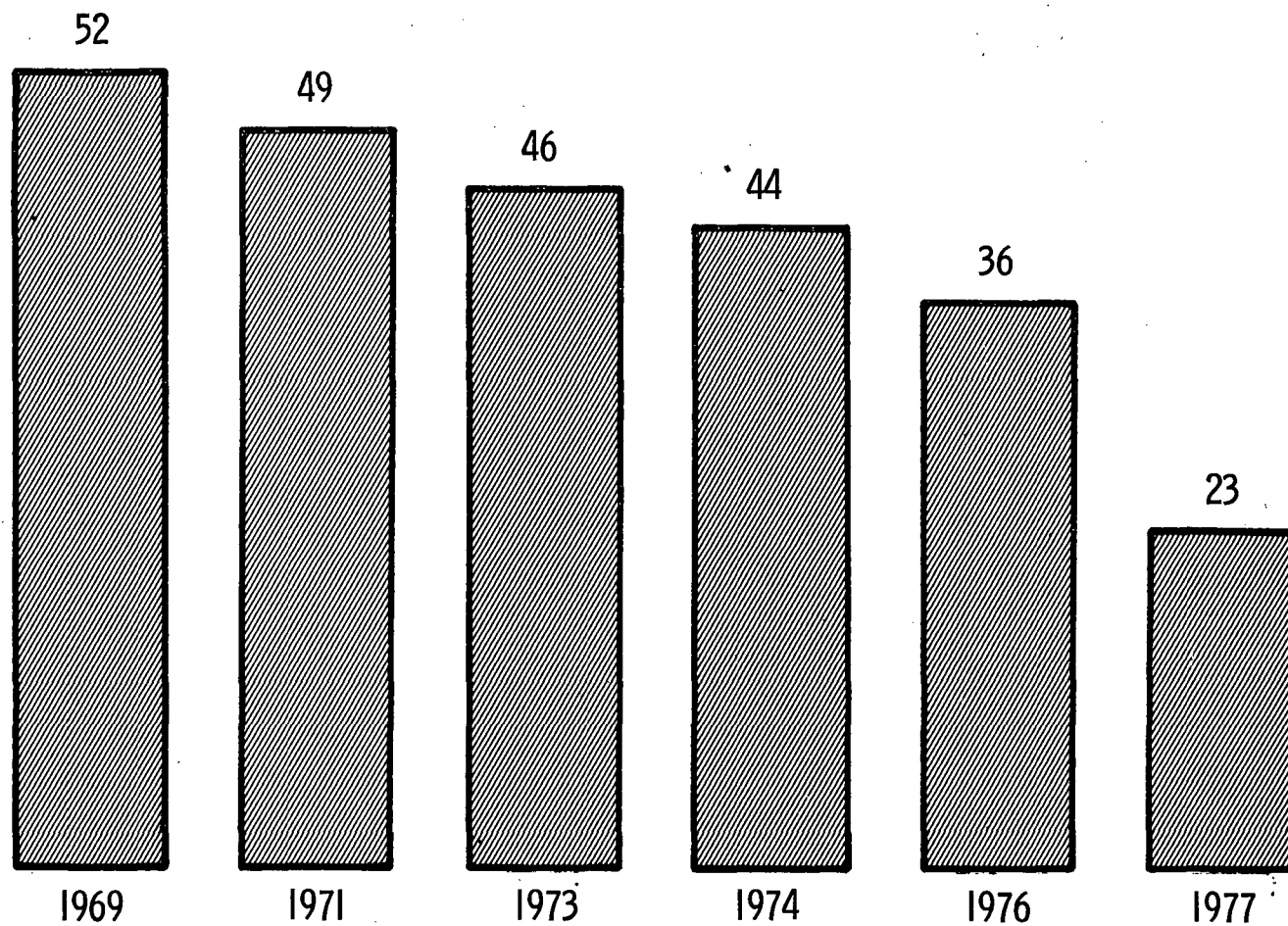


Figure 4.11 PERCENTAGE OF NATIONAL POPULATION OBJECTING TO EXCESSIVE MILITARY SPENDING (Source: Gallup Abstract).

these views. In recent years, there has also appeared in print increasing criticism of government agencies in general, as well as those specifically directed against the military. These developments may have influenced the degree of public support of governmental institutions.

The air cargo needs of the American military are directly related to its mission to move troops and material rapidly wherever they may be needed to counter threats against "U.S. interests". The concept of U.S. interests is a rather broad one seldom clearly defined. What sort of situation may be conceived as a threat to U.S. interests? To which parts of the world will the American military be called upon to move troops and material to protect such interests? These are situations questions that directly relate to this concept (ref. 57).

In the budgetary proposal for the Fiscal Year 1979, the Carter administration has explained the goals of the American military as follows:

Protect America's people, its institutions, and its lands from aggression.

Preserve an overall military balance between the United States and its allies, and the Soviet Union and its allies, that is at least as favorable as the present balance.

Maintain essential equivalence in strategic nuclear deterrence with the Soviet Union, preserving the capability to launch a retaliatory second strike that would inflict unacceptable damage.

Maintain sufficient power, together with our allies, to defeat any aggressors swiftly, with full recovery of any territory lost initially.

Seek international agreements to limit and reduce all armaments, to prevent proliferation of nuclear technology, to restrict arms trade, to settle disputes by peaceful means, and to strengthen international stability.

A broad interpretation of these defense goals might involve the mobilization of American Armed Forces and their dispatch virtually anywhere in the world. What will defense needs mean in terms of these goals in the year 1990 and thereafter? The post-Vietnam era has introduced some realistic changes in the goals of the American Armed Forces. At present, the American military perceives its international role in terms of the protection of NATO members. In the absence of any significant political change in the individual countries of Europe, it is most likely that the American commitment toward NATO will continue.

Now, we may proceed to analyze the air cargo needs of the American military as indicated in the documentary material (ref. 59). The Department of Defense desires the following air cargo capability for the immediate future.

Military Air Cargo Needs of the Future

General: Capability to Airlift 370 000 tons to Europe in 30 days

Cargo: 93 000 tons outsize - 230 000 tons oversize - 47 000 tons bulk

In a position paper prepared in March 1978, the Military Airlift Command (MAC) outlined their concept of the military C-XX; a large cargo transport aircraft that would meet their future transportation needs. A significant aspect of their proposal is that the C-XX be an all-cargo advanced aircraft that will meet both civil and military needs. These aircraft would be owned and operated by the airlines for their civilian cargo services, but in case of national emergencies, the military would acquire them for supporting their overseas mission. The military projects a total buy of 60 C-XX aircraft between 1990 and 1996 out of a total U.S. buy of 300.

This summarizes the military advanced air cargo needs as projected by the military position, but an evaluation of such needs is extremely difficult for a variety of reasons. In an earlier evaluation, the GAO criticized the specific project of airlifting 370 000 tons of cargo to Europe (ref. 59). The GAO criticisms were directed at a non-availability of airfields in Europe, refueling problems, and expense of the airlift operation. These criticisms are largely applicable in the case of C-XX proposal.

Since a major thrust in the military proposal for the advanced air cargo aircraft involves the defense of the NATO nations, it seems pertinent to examine this aspect in the context of the European nations.

In a meeting of the NATO leaders held in Paris on February 17, 1977, under the auspices of the Atlantic Institute, the issue of new large transport aircraft was discussed. A member of our research team interviewed an observer of this meeting in Paris (ref. 60). This interview data and a review of the proceedings of the meeting led us to infer that the leaders of the European nations present came to the following conclusions:

- a. There will be a continuing and increasing need for strategic air transport for deterrence, mobilization, and resupply of NATO forces in Europe.
- b. International cooperation may be essential for the development of a new large air transport aircraft.
- c. Such cooperative approach would be a way to achieve weapons system standardization desired by the NATO participants.
- d. A major European delegate at this meeting suggested specific plans for a joint European-U.S. effort to produce a large cargo aircraft.

The nations of Western Europe face a continuing dilemma in respect to their relationships with the United States. Most of the nations of Western Europe perceive the need for U.S. presence, but they are extremely sensitive about the dominant position of the U.S. aerospace industry (ref. 61). They openly discuss the need to revive the European aerospace industry and achieve access to protected American markets. These concerns have led European nations to undertake projects like the Anglo-French Concorde and other collaborative arrangements to produce aircraft (ref. 62) (Table 4.12).

A content analysis of the proceeding of the Symposium of European Armament Policy held in Paris (3rd-4th March, 1977) provides some clues to understanding their motivation (Table 4.13).

This analysis suggests the following inferences about the air cargo needs of the American military and the options associated with such needs.

- (1) First, it is clear that in the face of world-wide budgetary pressures (including the U.S.A.), the air cargo needs of the U.S. military may have to look toward the "concept of sharing".
- (2) Second, since the air cargo needs of the American military are directly related to contingency plans for European defense, European collaboration deserves detailed study. There is adequate evidence to suggest that European nations want collaboration in at least one area of advanced cargo aircraft production.

4.5.1. European - U.S. Collaboration

The preceding discussion has been analyzed exclusively from the point of view of the United States. Collaboration in aircraft production can also be analyzed from the world point of view.

It seems all nations of Western Europe are concerned about cuts in their defense budgets. Some are specifically concerned about the lack of support for the military among the younger generation. They do not perceive a supportive attitude toward military expenditure among those members of their populations that have not experienced war. Collaboration in meeting defense needs could, ease pressure on their defense budgets. Collaborative production of a C-XX type advanced cargo aircraft is one attractive option for the United States, but as discussed earlier in this chapter, institutional constraints impede its realization. There are many dimensions of collaborative aerospace enterprise and therefore an European-U.S. collaborative venture raises many interesting questions. What shall be the nature of aerospace enterprise? How will the American aerospace industries participate in such organization? What will be the role of the various governments involved? What will be the role of intra-European political structures like EEC and WEA? There are many such questions that deserve systematic exploration.

Table 4.12

AVIATION RELEVANT CONCERNS OF DEVELOPING NATIONS*

Concerns	Asian Nations (N-12)	African & Middle East (N-25)	Latin American Nation (N-7)	All Nat. (N-44)
Developing Infrastructure	66%	84%	71%	77%
Equal Share In Air Traffic	16%	8%	0%	9%
Expansion of Market	8%	4%	14%	6%
Economic Development Through Aviation	41%	16%	14%	22%
Politics of Aviation	33%	28%	28%	29%
Regulation of Market	16%	12%	0%	11%
Concern of Environmental Impact	8%	4%	0%	4%

* Based on a thematic content analysis of the excerpts from the speeches of the delegates to the 22nd Assembly of ICAO, Montreal, Sept. 13 - Oct. 4, 1977.

Note: Percentages total more than 100% due to multiple themes identified in the speeches of most delegates.

Concerns of Certain European
National Elites in the Area of
Western European Defense Policy
(asterisk where concern exists)

Themes Emphasized as Rationale for Collaboration in Defense Production

<u>Nation</u>	Budget Cuts	R & D Costs	Imports from U.S.	Excessive Overseas Sale	Balance with Warsaw Pact	Common Security Policy	Transatlantic Competition	National Independence	European Competition	Standardization	Energy Crisis
Britain	*	*	*		*		*	*	*		
France	*	*	*	*	*	*	*	*			
West Germany	*		*		*	*			*		
Belgium	*	*			*				*	*	
Netherlands	*		*		*	*				*	
Luxembourg	*		*		*					*	
Italy	*	*			*		*			*	*
Norway	*				*					*	

Source: A thematic content analysis of the official record of
the symposium on European Armament Policy, 3rd-4th March 1977

Table 4.13

4.5.2. Concerns of the Third World Nations

United Technologies has studied the relevance of less developed nations to advanced aircraft transport (ref. 63). The findings of this study suggest the following conclusions:

- (1) Most of the aircraft required by developing countries could be the same types as are used by the United States and other developed nations.
- (2) While the needs of developing countries for large cargo aircraft are expected to be small compared with the developed countries, this market sector may represent an important supplement to the production base. Such optimistic suggestions have to be evaluated in the light of certain broader questions about the aviation relevant concerns of the third world nations. How do these third world nations perceive their role in the world aviation industry? Are they also concerned about the dominance of western countries (including the U.S.) in aerospace market? How are their orientations toward such questions likely to influence their willingness to accept the development of advanced cargo aircraft by the U.S.

It appears that most developing nations are primarily concerned about the cost of developing an infrastructure to support modern aircraft. A number of problems may be identified in this area. The delegates to the assembly seemed highly concerned about the cost of maintaining such an infrastructure.

Secondly, considerable emphasis was placed upon what may be called "the politics of aviation". Among other concerns, the developing nations emphasized such problems as economic development, market expansion, market regulation, and the environmental impact of the expansion of general aviation.

Such analyses suggest that the developing countries may be a potential supplementary market for large cargo aircraft, but the politics of the third world might create some problems for marketing American aircraft in these areas.

4.6 FUTURE AND LONG TERM IMPACTS

We have said earlier in this report that we wish to avoid catastrophic failure through overcommitment of resources to the ACIS (Section 4.1). We have also said that the supply of cheap oil will be progressively depleted in the time period we are planning for (Section 4.2). We have not predicted that the world will "run out of oil" during this period. A better way of conceptualizing the situation is to consider that the most easily accessed oil will be used first. Gradually, the easily accessible deposits will become exhausted and even if oil is discovered, say at 15 000 feet under the sea, it may be that as much energy will have to be invested to reach this oil as will be returned by burning it. Oil may still be recovered under these circumstances but obviously it will be for some other purpose than fuel.

Similar "energy budget" reasoning applies to substitute fuels such as hydrocarbon derived from coal, oil shale, methane or methanol. The energy return from these sources will provide a much smaller margin over the energy cost than is the case for the easily exploited oil deposits which we are currently mining out. These substitute sources might, however, sustain a "low energy economy" and we must therefore consider this as one of our options.

The role of government is crucial in planning for the development of air cargo beyond 2015. The air transport picture beyond the period planned for in this report is unclear, because we do not know what sort of energy base we will have. This is crucial because the energy base will determine our economy and hence our transportation needs. In planning for the future, it is suggested that we consider three alternative economies -- a hydrogen fusion economy, a high technology solar power economy, and a low energy economy. These appear to be our possibilities. Since we are talking about planning for the future, we will not even discuss a do-nothing or muddle-through approach; this is not planning, and if we adopt it, there is no future, at least, for air cargo.

The hydrogen fusion option offers the greatest potential for development but entails the greatest risk. In a hydrogen fusion economy, the available energy would be almost limitless and almost free. As a result, the value of time would increase inordinately and the demand for a high volume efficient air transport system would be virtually assured. In this possible future, the only constraints to growth would be the amount of pollution people could tolerate; the space available for transport activity; and, political irrationalities. The catch is, maybe it cannot be done.

The high technology solar power economy would be less energy-rich than a hydrogen fusion economy. In addition, there would be more favored places entailed by the very technology undergirding such an economy; e.g., bands under satellite power stations, areas with higher levels of irradiation, and regions near the sea coast. The distribution of population would conform to these more favored places.

The air transport system would thus be constrained in two dimensions -- energy availability and population distribution -- and would play a modest role in the overall economy. If this is the chosen future, then the 1990 system will form an admirable base for further modest incremental growth and network modification.

We can imagine something like the following development: A network of approximately fifteen hubs is in place by 1990. This network is served between major hubs by a plane like the Boeing 747 or the C-5A. Sometime during the 1990-2015 period, a high energy solar economy first supplements and then supplants our current hydrocarbon economy. As world surplus gradually builds up, there is more and more traffic on the ACIS. When volume builds to the point where three or four planes are required each transit period between most of the hubs, it will then become a sound investment to build a fleet of distributive-load aircraft to replace the old long haul planes.

If this is how things turn out we might see a production run of 600 000lb payload spanloaders. Naturally, if these large craft are put into service, considerable investments will have to be made in airports and facilities. For a good preliminary description of the system sketched here, the reader should see reference 64. One design concept for a distributive load freighter is shown on the right in Figure 4.12. The design on the left represents a plane intermediate in size between the largest freighters now in service and the span loader.

If the low energy economy is the option exercise, then the picture is radically changed. There is still need for air transport in this alternative future but we are talking about a world where the pace of events will be slow and economic activities will have a greater degree of local orientation. In this foreseeable world, the use of lighter than air ships to move large volumes of low value commodities from the interior of the continents is quite likely to occur.

In an economy where conservation is emphasized, human and animal labor is substituted for power machinery, and commodities are stored for local consumption rather than transported, there will be a general decline in the efficiency of all land transport systems and air ship exploitation of markets remote from water transport will become attractive.

As world population rises toward nine billion persons in the early part of the next century, and as the trend toward concentration of people in urban areas continues, sheer congestion and degradation of roadways should make the small airship competitive with the truck for loads in the 20 tonne range. Such an airship would (a) cost less than a comparable lift plane, and (b) have a higher transport efficiency than a truck under the conditions described above. A good discussion of these efficiencies can be found in ref. 65.

In order to plan beyond the next equipment cycle, we need to know what kind of future we are planning for, because air cargo planning is directly dependent on energy planning. Sometime soon a definite commitment to the future will have to be made; we cannot hold our options open indefinitely.

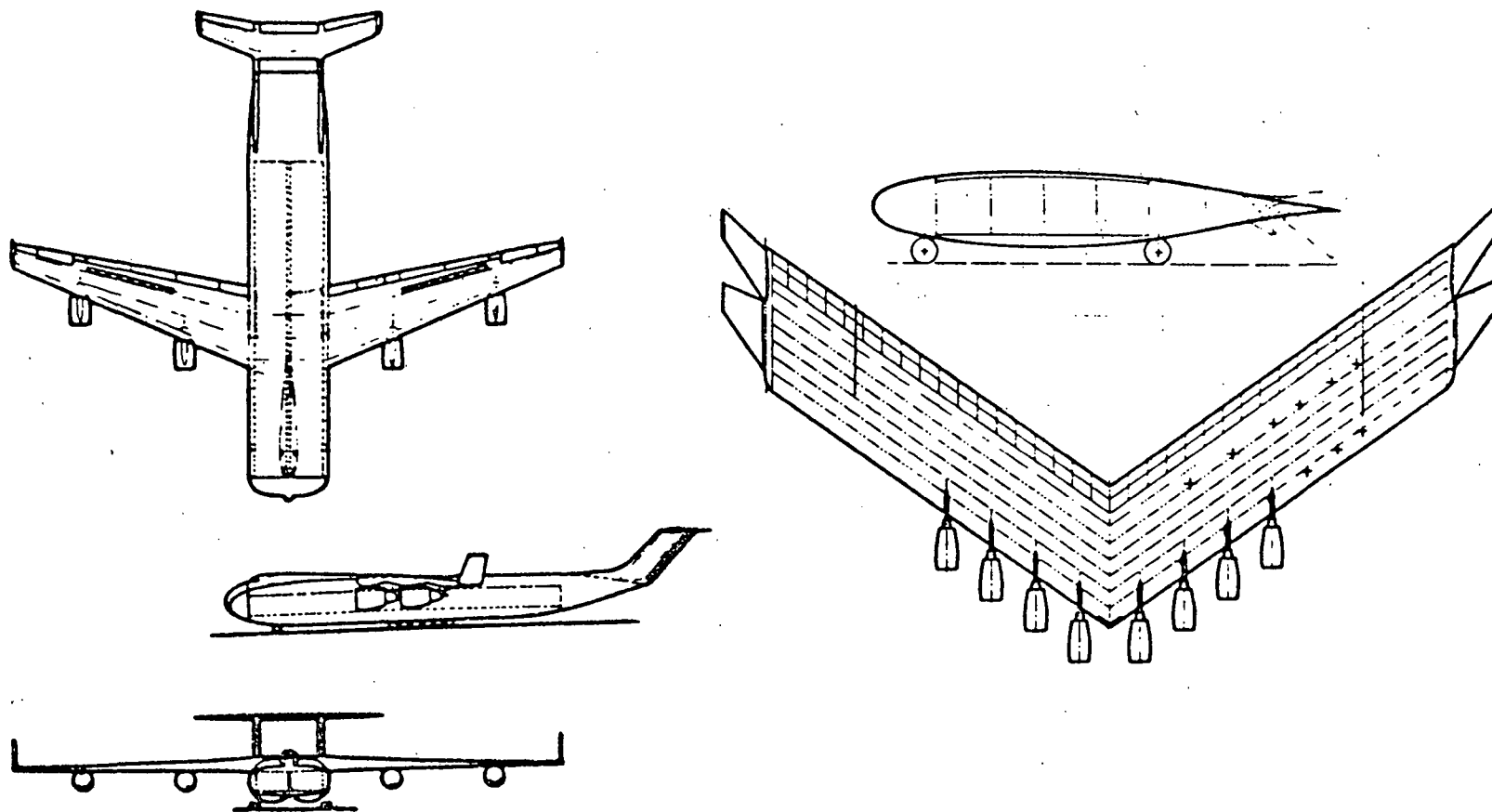


Figure 4.12 PROPOSED FUTURE AIRCRAFT (Sources: Whitehead, Allen: Technical and Economic Evaluation of Advanced Air Cargo Systems. NASA TM 78672, 1978, p. 20).

When we look toward the mid range future, we are quite optimistic about the prospects of air cargo. As long as a cosmopolitan form of social organization persists, whether the energy expended per capita is low or high, there should be a demand for freight moved by air. However, the level of energy expended will probably determine what kind of air transport is employed.

We now turn to a consideration of the long range pervasive impacts of the ACIS. The first of these is the impact of vertical integration. Vertical integration should result in labor efficiencies; thus, short term impact will be loss of payrolls in some areas. Furthermore, because integration will limit the number of competitors, some shippers may experience temporary loss of service. It is expected that these adverse impacts will in the main be of short duration and local in their affect.

If integration should work properly, cost-savings should result in higher earnings for the firms involved. Higher earnings should lead to lower rates for the same level of service or better service at the same rate. This should lead to economically healthy firms. Lower rates, better service, and a healthy air cargo system will be a stimulus to economic growth and will be beneficial to the whole economy.

Integration may also cause the economy as well as the air cargo system to attain a better balanced use of resources. Service by some modes would be decreased and service by other modes would be shifted from less productive uses to more productive employment. In the long run, labor, shipper, communities, and the general public would benefit from better uses of resources. The second long term pervasive impact we shall address is the ACIS second order social impacts.

A convenient way of thinking about what we shall call the secondary social impacts of the (ACIS) can be acquired by considering the predilection of many contemporary sociologists to turn to a new paradigm.

The new paradigm portrays individual humans as nodes in a network with each node having ramifying connections to many other nodes. In most instances, these networks are perceived by sociologists as having low degrees of connectivity. There is little feedback by way of intervening nodes to stabilize the network and hold the individual in a nexus of expectations. Beyond the direct "exchange" between parties, there is little effect on the parties to a social transaction.

When we ask why this paradigm is displacing the simpler paradigm of structural functionalism, derived primarily from anthropologists, with its implicit assumption of ramifying secondary feedback loops, we reach a conclusion which may surprise some persons: The new paradigm simply fits contemporary society better than the old one did.

What we are saying is that this is because the very nature of the ways human beings relate to one another is different than it was seventy years ago. Confronted with the modern scene the modern sociologists can, in most cases, only arbitrarily draw group defining boundaries and any normative order he

uses is of such a high level of abstraction as to convey almost no information.

Upon reflection, it is reasonable to expect that the ACIS will contribute to a continuation of the trend toward rendering the social life of Americans suitable to explanation only by means of network analysis. To the degree that it makes it possible for larger numbers of persons to interact impersonally with one another, it will help to create conditions which will make the network paradigm necessary.

The third long term impact of the ACIS, we perceive, is that in the international sphere it should tend toward generating interdependencies among the trading parties. It is quite possible that several nations could contribute items which form some complex assembly. This is easy to conceive at the outset, but it is only the tip of the iceberg; over time this interdependence could ramify throughout entire segments of the economy. We are here picking up another thread of the same fabric we were considering in Section 4.3 The message is the same in both instances; the ACIS is a force for interdependency; depending upon ones value system, this can be judged as either good or bad.

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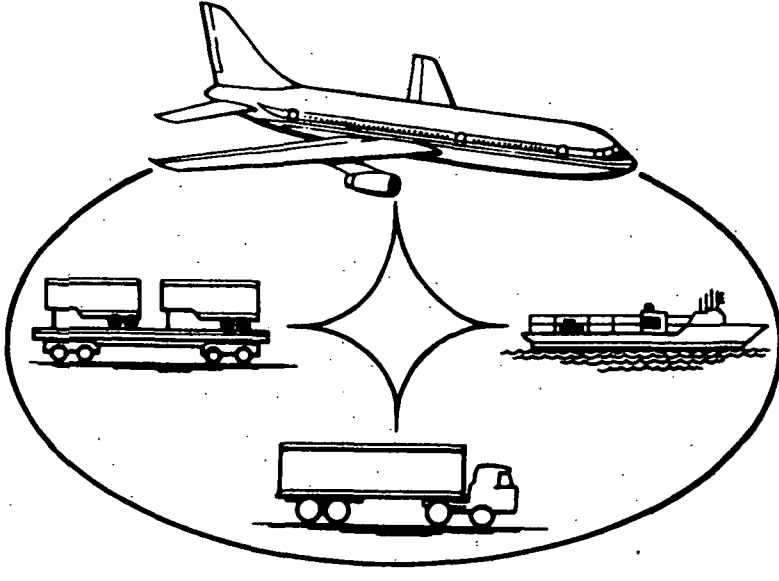
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IMPACTS

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IMPACT OF THE ACIS

Introduction

It is one thing to use modern technology to develop a system; it is another to ignore the impacts such a system will have on the surrounding physical and cultural environment. The designers of any transportation system must insure that the long-term viability of the environment is preserved.

The human race is constrained by its environment; specifically by such aspects as food, land, water, climatic change, energy, hazardous substances, non-fuel minerals, human stress, social tension, ecological stability, management, and global organization (ref. 1).

Over the years the development of air transportation has resulted in many social and economic impacts. In some of the earlier books on air transportation, predictions were made about changes that would result from increased air transportation. Many of these changes have become such an accepted part of everyday life that they would no longer be regarded as impacts. For example, the following social and economic impacts were predicted in 1951 (ref. 2).

1. Changes in population growth resulting from:
 - a. aerial warfare - decrease population
 - b. quick transportation of emergency supplies to disaster areas - increase population
2. Redistribution of population resulting from:
 - a. development of resources in inland Africa, Asia, and South America
 - b. population shifts to meet increased labor needs of the U.S. west coast
3. Expanded markets for products
 - a. Aviation enables salesmen and buyers to make more frequent contacts.
 - b. California produce will be sold on the east coast.
4. Recreational impacts
 - a. Vacations to more distant places will become common.
 - b. Areas in which sports contests are held will be widened.
5. Impacts on education
 - a. Study of physics of flight as well as biology of organisms in the air will become an important part of textbooks.
 - b. Concepts of geography will be transformed through the airplane's ability to enter the spherical air ocean linking all points on the earth's surface.
6. Measurement of distance will be in terms of time.

Since 1970, when the National Environmental Policy Act (NEPA), PL 91-190 became a part of U.S. law, the procedure to determine the impacts of a system or project has been addressed and in most cases better understood than at any previous time. This was due to the creation of a major new responsibility for those concerned with any planning project that may have a significant effect on the environment; they have to produce a detailed statement of the environmental impact of the proposed action.

"Accordingly, agencies and consultants have had to consider a whole new set of factors in project planning, and to do so in a systematic way. In preparing the environmental impact statement, all relevant factors must be identified, the nature and seriousness of the project's impact on them must be assessed, and the data must be so presented as to make informed, rational decision-making as straightforward as possible." (ref. 3)

The obligation to be concerned about the environment, the importance of impact assessment, and the recognition that many of the above factors would be impacted by our designed system were responsible for the development of an impact team to evaluate the possible impacts of the ACIS.

Structure

The team consisted of at least one member of each of the original four teams (Fig. I.1).

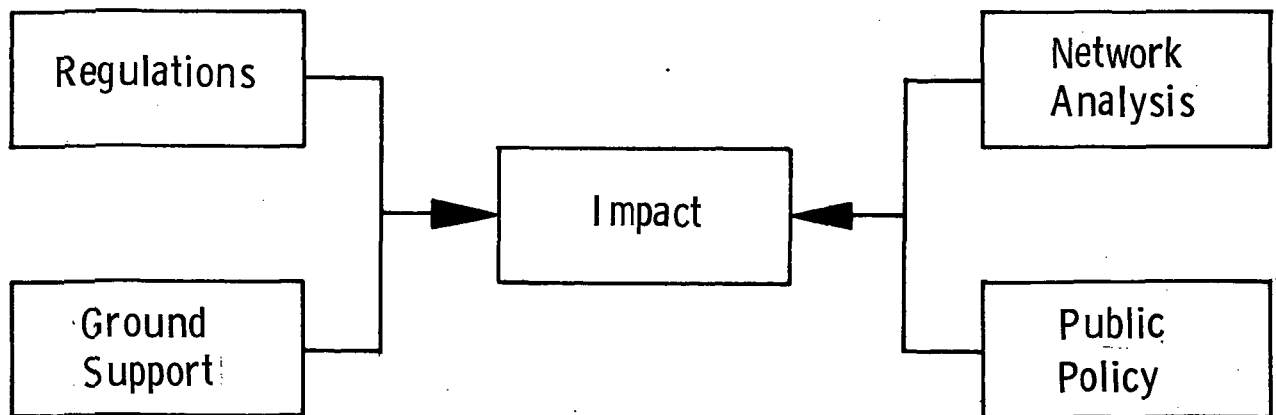


Figure I.1 IMPACT INPUTS

In this way, inputs from all four teams were funneled into a central group for discussion, organization, and evaluation.

A team objective was to identify and, if feasible, explain the interaction of each task group's portion of the ACIS and possible cultural and physical concerns.

Two definitions of the word "impact" were recognized:

- (1) Simply stated, "impact" means change -- any change, positive or negative -- from a desirability standpoint
- (2) "An impact can be defined as any change in the physical -- chemical, biological, cultural, and/or socioeconomic environmental system that can be attributed to human activities relative to alternatives under study for meeting a project need." (ref. 4)

Methodology

All participants received a memorandum which explained the need to identify impacts of the ACIS. The memorandum included two examples of impact assessment methodology; these examples are shown below (ref. 5).

Planning and Design Phase

1. Impact on land use through speculation in anticipation of development
2. Impact of uncertainty on economic and social attributes of nearby areas
3. Impact on other planning and provision of public services
4. Acquisition and condemnation of property for project, with subsequent dislocation of families and businesses

Construction Phase

1. Displacement of people
2. Noise
3. Soil erosion and disturbance of natural drainage
4. Interference with water table
5. Water pollution
6. Air pollution (including dust and dirt and burning of debris)
7. Destruction of or damage to wildlife habitat
8. Destruction of parks, recreation areas, and historic sites
9. Aesthetic impact of construction activity and destruction of or interference with scenic values
10. Impact of ancillary activities (e.g., disposal of earth, acquisition of gravel and fill)
11. Commitment of resources to construction
12. Safety hazards

Operation of Facility-Direct Impacts

1. Noise
2. Air pollution
3. Water pollution
4. Socioeconomic
5. Aesthetic
6. Effects on animal and plant life (ecology)
7. Demand for energy resources

I. Physical and chemical characteristics

A. Earth

1. Mineral resources
2. Construction material
3. Soils
4. Land form
5. Force fields and background radiation
6. Unique physical features

B. Water

1. Surface
2. Ocean
3. Underground
4. Quality
5. Temperature
6. Recharge
7. Snow, ice, and permafrost

C. Atmosphere

1. Quality (gases, particulates)
2. Climate (micro, macro)
3. Temperature

D. Processes

1. Floods
2. Erosion
3. Deposition (sedimentation, precipitation)
4. Solution
5. Sorption (ion exchange, complexing)
6. Compaction and setting
7. Stability (slides, slumps)
8. Stress-strain (earthquake)
9. Air movements

II. Biological conditions

A. Flora

1. Trees
2. Shrubs
3. Grass
4. Crops
5. Microflora
6. Aquatic plants
7. Endangered species
8. Barriers
9. Corridors

B. Fauna

1. Birds
2. Land animals including reptiles
3. Fish and shellfish
4. Benthic organisms
5. Insects
6. Microfauna
7. Endangered species
8. Barriers
9. Corridors

III. Cultural factors

A. Land use

1. Wilderness and open spaces
2. Wetlands
3. Forestry
4. Grazing
5. Agriculture
6. Residential
7. Commercial
8. Industrial
9. Mining and quarrying

B. Recreation

1. Hunting
2. Fishing
3. Boating
4. Swimming
5. Camping and hiking
6. Picnicking
7. Resorts

C. Aesthetics and human interest

1. Scenic views and vistas
2. Wilderness qualities
3. Open space qualities
4. Landscape design
5. Unique physical features
6. Parks and reserves
7. Monuments
8. Rare and unique species or ecosystems
9. Historical or archeological sites and objects
10. Presence of misfits

D. Cultural status

1. Cultural patterns (life-style)
2. Health and safety
3. Employment
4. Population density

E. Constructed facilities and activities

1. Structures
2. Transportation network (movement, access)
3. Utility networks
4. Waste disposal
5. Barriers
6. Corridors

IV. Ecological relationships

A. Salinization of water resources

B. Eutrophication

C. Disease-insect vectors

D. Food chains

E. Salinization of surficial material

F. Brush encroachment

G. Other

Impact Matrix

Throughout the project, impacts were noted by the participants, both individually and in the task group teams. The impacts were collected by each team's representative to the impact task group. Near the completion of the project, the impact team developed a list of the identified impacts. These were categorized as to type and used to develop an impact matrix. The matrix went beyond just identifying the relationships because it enabled the team to evaluate the significance of the impact via a numerical impact evaluation.

Each cell of the matrix indicated an interaction between a task group/geographic area and an impact. The importance of an interaction was related to the significance (assessment of the consequences) of the anticipated interaction. The assignment of the numerical value was based on the subjective judgement of the appropriate task group team.

The impacts were divided into two categories: physical and cultural. These two categories were further divided into technology, natural resources, and environmental in the physical category and economic, social, and political in the cultural category. Each subcategory was further subdivided into impacts recognized by the summer group.

Impact Matrix Results (See Interaction Matrix, Table I.1)

Following is the final list of impacts and the individual impact intensity caused by the ACIS.

- I. Physical
 - A. Technology
 1. Maintain U.S.'s aircraft technology lead (High)
 2. Further mechanization skills (Moderate)
 3. Lower storage inventories/quicker response times (Moderate)
 - B. Natural Resources
 1. Fuel Consumption
 2. Non-Fuel mineral consumption (Moderate)
 3. Water supply demand (Moderate)
 4. Wildlife displacement (Low)
 5. Land Use (Moderate)
 - C. Environmental
 1. Noise (High)
 2. Air (Moderate)
 3. Water (Low)
 4. Solid waste (Low)
- II. Cultural
 - A. Economic
 1. Improve international trade balance (High)
 2. Airline route system (High)
 3. Ability of aircraft industries to attract capital (Moderate)
 4. Older aircraft obsolescence (Moderate)
 5. Taxpayer cost (subsidies) (Low)
 6. Payroll (Moderate)

7. Increased viability of airline industries (High)
8. Industrial developments close to airports (High)
9. Increased taxes to pay for greater public services (Moderate)
10. Residential values (Low)
11. Income levels change (Low)

B. Social

1. Unemployment-reduce (Moderate)
2. Unemployment-increase (Low)
3. Urbanization (Moderate)
4. Airport road access congestion (Moderate)
5. Organization structure of airlines (Moderate)
6. Organization structure of transportation system (Moderate)
7. Movement of population (Moderate)
8. Increased public service needs (Low)
9. Increased housing needs (Low)

C. Political

1. Area growth (Moderate)
2. Government elected representatives (Low)
3. New electorate boundaries (Low)
4. New labor-social force of carriers and forwarders (Moderate)
5. Regulatory agencies organization (Moderate)
6. Regulation change (Moderate)
7. Population characteristic change (Low)
8. International Markets (High)
9. Increased International Cooperation (Moderate)

The greatest positive interaction occurs in the following specific impacts:

Airline route system (Economic)
 Fuel consumption (Natural Resources)
 Industrial developments close to airports (Economic)
 Improve international trade balance (Economic)
 Increased viability of airline industry (Economic)
 International Markets (Political)
 Maintain U.S.'s aircraft technology lead (Technology)
 Noise pollution - hearing loss (Environmental)

Many impacts that are of low or moderate importance could be rated high in local situations or at local areas. Also, the importance of environmental impacts are less than some individuals might suspect. Only noise pollution was of high importance. This is due to ACIS representing only a small portion of the environmental impact of the aircraft industry. This is also why the social impacts were not as important as might be expected.

By totaling the rows and columns, the most important or serious grouped impacts were determined. Table I.1 is a further compilation in order that the overall interaction of the major impact topics and the task group/geography areas can be related.

The network section is dominant in positive effects, both nationally as well as locally. The ground support interaction is strong locally while both

the regulatory and public policy sections show a national interaction with very little direct local involvement.

It becomes evident that the two most important impact sections, based on average interaction per specific impact, are the economic (10.0) and technological (9.6) with natural resources (8.4) third. This ranking indicates a cyclic phenomena problem for the ACIS. Without the financial capacity and the advancement of technology (which needs capital to be accomplished) the ACIS may not be developed. However, it also indicates that by implementing the system, there is a possibility of helping to alleviate the economic and technologic problems which presently face the aircraft industry.

	Regulatory		Network		Ground Support		Public Policy		Local Total	National Total	Total	Average Impact
Economic	4	13	25	17	20	8	7	16	56	54	110	10.0
Social	1	6	11	10	19	4	2	7	33	27	60	6.7
Political	1	11	10	11	8	0	7	15	26	29	55	6.1
Cultural (Subtotal)	6	30	46	38	47	12	16	38	115	110	225	7.7
Technology	-3	5	13	17	6	3	0	7	16	32	48	9.6
Natural Resource	1	1	13	13	11	4	-2	1	23	19	42	8.4
Environmental	6	5	19	13	22	3	-8	-2	39	19	58	4.9
Physical (Subtotal)	4	11	45	43	39	10	-10	6	78	70	148	6.7
Total	10	41	91	81	86	22	6	44	193	180	373	7.4

Local



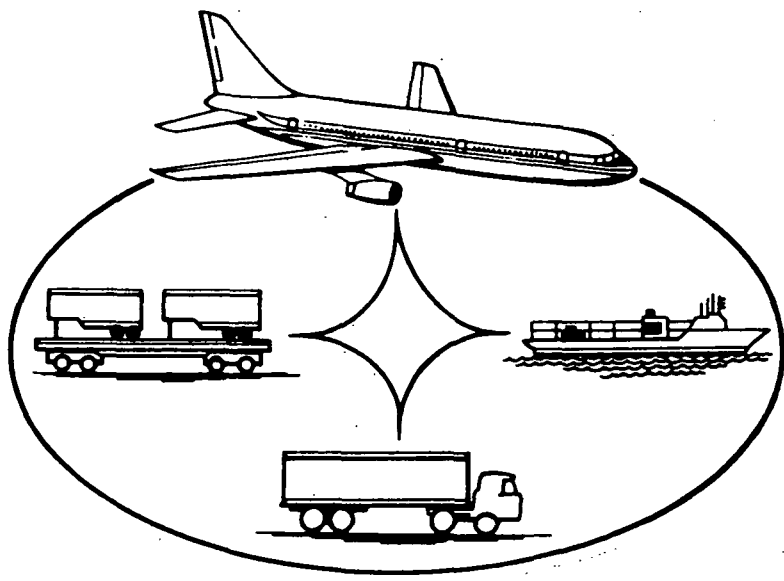
National



Table I.1 Interaction Matrix

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SUMMARY AND RECOMMENDATIONS

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SUMMARY AND RECOMMENDATIONS

Summary

This report has investigated four selected aspects of the air cargo industry with a view to system and aircraft advancement. These aspects are network design, ground support, regulation, and public policy. All of these areas were considered in the context of the assumptions elaborated in the first chapter. The assumption of an incrementally larger plane as the large cargo aircraft of the 1990's is of particular importance to the analysis and conclusions in the network and ground support sections.

Network Design

The 1990-2015 network was envisioned to differ from that in place currently not in kind but in scope. Common carrier air freight operations would be arrayed in a hub and spoke alignment with a limited number of high volume city pairs connected by non-stop flights. The major hub, minor hub, and local airport trichotomy would be reinforced by the increased use of the LCA (Large Cargo Airport) among major national and international hubs.

Aircraft in the 1990's would vary according to the types of ports which their flights connected. Flights between hubs would be carried out in new large craft of recent integration and existing planes of longer service. Between minor and major hubs a variety of craft could serve; we have recommended a new dedicated freighter. A multiplicity of planes would serve between local airports and hubs. These would range from advanced, yet to be marketed craft, to possibly some residual venerable workhorses like the DC-3.

In an effort to use craft most economically, dynamic scheduling of full freight flights is likely to be generally practiced, following the example of Federal Express. This will also decrease the time taken in collector flights, thereby enhancing the total delivery period capabilities of air cargo service. These capabilities will also be enriched by technical and institutional innovations which will facilitate door-to-door movement of freight. The interstate highway system will, in effect, become an extension of the air network in these movements.

The environmental and social impacts of network design will be, on balance, favorable to quite favorable. Little new land in urban areas needs to be dedicated to airports and the aircraft mix will be better environmentally than the current one. New industries with air eligible cargos are likely to locate proximate to air cargo facilities, often in interstate beltline industrial parks already in place or planned for development. On the negative side, it remains that air freight is energy intensive compared to other modes, and that some construction associated with large freighter capabilities may cause temporary local disruptions. An increased intensity of night flights may be unpleasant for residents near airports, primarily at major hubs.

Ground Support

Ground support was construed broadly to mean physical structures, operational procedures, and consumer information techniques which facilitate the movement of cargo from and to the air system. The establishment of one carrier responsibility for door-to-door shipments is considered essential to adequate consumer service. Currently forwarders provide this sort of service and airlift carriers need this capability to compete with the trucking and COFC modes. There are several problems which must be resolved to allow single waybill service. Which carrier insures which segment(s) of the total haul is problematic. Does the company providing the airlift and issuing the waybill insure all segment or only the air stages? Should the same amount of liability be assigned to all segments of the haul, or should the varying levels of liabilities which currently exist among modes be maintained? Should airlines be able to acquire trucking companies? How are revenues divided when a single waybill is issued?

Assuming these issues are resolved and single waybills can be issued by air carriers, several problems in marketing and services remain. First, sales personnel usually have only the sketchiest notion of their client's operations, hence they cannot offer users services appropriate to their needs. Second, salespersons often are not totally familiar with their own operations and in some cases even their tariffs. Third, service currently is geared around small package and emergency cargos; rates and handling alternatives for other types of air cargo limited.

In order that quick transit, with or without single waybills, can be executed, the 1990 terminal will have to evolve both in capacity and function. In addition to the small package building, which is the extent of the facilities at many airports, terminals will need direct facilities for intermodal containers and full air container loads. Total space for the terminal including staging area, plane aprons, open storage, and enclosed storage will have to be expanded on the order of three or four times compared to current facilities. This is due to the number and types of vehicles which will interface with the airlines in the 1990 system. It was concluded that both gate arrival and remote terminals were infeasible because of cargo transfer problems and because they would abrogate economies of scale in handling cargo.

All ground support developments link to efficient movement of intermodal containers. The 6.1m (20ft) box is the container which will have greatest compatibility between air and other modes. This recognizes that the type of freight which is air eligible in value and density considerations most often moves in less than carload (LTC) lots. The 6.1m container is appropriate to this size of shipment. A problem with intermodal containers is their high tare weight, a weight which can be up to one-third of the total payload of the aircraft.

Insofar as improvements in consumer information and the marketing system will increase traffic, detrimental impacts associated with more flights, e.g. noise, can be associated with changes in the ground support system. There may be considerable environmental conflicts at some airports when the need for additional land for terminals becomes evident. The intensity of the problem will

vary locally depending on the amount of property already held by the airport authority and how much must be acquired. A third problem area is the increase in volume of truck traffic on access roads during the hours of terminal operations. Greater truck traffic on residential arterials proximate to the airport can be expected. This may contribute more to air and audio pollution than the aircraft for freight movement.

Regulations

Regulations which pertain to air cargo movements can emanate from federal, state, and local governments. In addition, international agreements can affect landing rights and rate schedules. In the United States, the primary direct regulation of air cargo is done by the FAA and CAB. The FAA has historically regulated and continues to regulate safety standards for airports and aircraft. The CAB has regulated the economic aspects of the industry, i.e. tariffs, routes, and schedules. The deregulation of air cargo is, in fact, an abrogation of prerogatives by the CAB, which may be temporary. Its actions should have minimal effect on the 1990 network or rates if this policy continues.

Intermodality of shipment is limited by current regulatory structures. A primary problem exists in the fragmentation of authority between the CAB, FAA, ICC, and the Maritime Commission. Currently, vertical integration of transportation companies is difficult, if not impossible, because of varying prohibitions and procedures among these agencies. There are also some inherent differences in mode economics and operational practices which limit intermodality of cargo transportation. An airline cannot own a common carrier trucking fleet by regulatory prohibition. Even if it could, the operating cost structures vary enough between these modes that the integration of these two operations is difficult.

While the economic regulation of the industry is being decreased by current policy, the regulation of safety is not likely to be diminished. In anything, as pollution standards become a routine part of public health and safety considerations, the regulatory sphere of the FAA is likely to increase. In addition to noise and emission standards for aircraft, the agency may expand its activities in the area of design and configuration of airports on environmental safety grounds. Certainly the traffic control function of the agency will not be diminished.

Whether or not the FAA enters the arena of airport design and restriction of proximate land use, there will be local regulations in this area. Where new designs are under consideration, it is likely that zoning limitations on single-family residence in the approach affected land around ports will be common. Where residential land use is already established adjacent to the airport site and in flight paths, other local regulations can be expected, e.g., curfews.

The primary impacts of regulation will depend on the appropriateness of rules and the timing with which they are implemented. Changing federal regulatory practices may adversely affect elements of the industry whose operations are geared to a set of regulatory framework. Likewise, some policies pertinent to proximate land use can create unfavorable situations of localized real estate value.

Public Policy

Government involvement in the research, development, promotion, financing, and subsidy of aircraft and airlines is pervasive. The government is also a major owner of freight and other military aircraft. It has legitimate spheres of activity: 1) to provide an air force for national defense and 2) to insure an adequate civilian fleet and ground support for common carriage. The way in which these spheres are handled is quite different.

Military needs have generally been dealt with directly. A fleet of fighters, bombers, freight, and other craft are owned by the federal government. These are at the state of the art in technical applications and modified as new advances occur. Often these advances are the result of government research to improve the performance of military planes, e.g., the supercritical wing. For reasons of economy, massive transport of troops by air is provided through a national emergency reserve pool of the fleets of the major airlines. For these same reasons, the military is interested in a reserve fleet of cargo carriers and even joint development of a military/civilian large dedicated freighter.

There are, however, considerable impediments to this development effort. First, the military wishes entry to less developed and smaller airports than is necessary for civilian purposes. This requires a less efficient design for cruising, hence a less fuel efficient craft. Commercial freighting operations are not willing to accept the increased operating expenses. Second, the military requires high wing craft for loading and lift, again fuel efficiency at cruising speeds is sacrificed. The military requires movement of outsized, high density cargos, e.g., tanks. This calls for heavy decks and a roll-on, roll-off capability. While the nose and tail bays to meet such needs are useful to civilian freighters, the ground level entrance and exit are not needed, and the heavy decks limit the amount of cargo which can be carried. Fourth, the military has an upper limit on the size of aircraft it desires. This is on tactical and versatility criteria. The size they desire is much smaller than the economy of scale for air operations, hence the military requirements again lock a commercial operator into a suboptimal craft. The discrepancy between optimal military and civilian large cargo aircraft is considerable.

A more feasible alternative than civilian/military development of an advanced craft built in the United States might be a multi-national consortium to produce a military freighter which may have civilian application. Models already exist for this cooperation in Europe with military fighter planes and civilian passenger craft. Perhaps a consortium of free world allies could produce the large military or commercial cargo craft if the development costs and risks were unacceptable to an individual country.

Some international cooperation and planning may be required in many future developments of the aviation industry. The total system uses a great variety of minerals, some of which are rare and some of which do not exist in the United States. Profitable manufacture rests on stable supplies of materials at acceptable costs. International and domestic programs affect stability and costs. Fuel availability and policy also comes into play here. A limited allocation of

petroleum resources to air cargo could constrain the industry to its current small package, emergency role. Successful commercial common carrier activity may depend on the development of synthetic or alternative fuels by the end of the 2015 time period.

These fuel limitations may necessitate new designs of radical departure from current aircraft for cargo carriage in the 1990-2015 period. If fuel is simply rationed, a larger aircraft would have a better efficiency rating than the size generally assumed throughout this study. Designs like the Boeing twin-lobe or the spanloader may be the response. In an extreme traditional fuel scarcity, alternative fuels, i.e. hydrogen or methane, would find use.

Recommendations

After reviewing the above information, the design team offers recommendations in the following five areas: 1) aircraft, 2) network structure, 3) ground support, 4) regulation, 5) public policy, and 6) future research and air cargo data development.

Recommendations concerning aircraft:

1. A new intercontinental range dedicated freighter should be developed. It should be capable of carrying at least 100 tonnes (220 000lb) at U.S. coast to Europe stage lengths and somewhat less at longer distances. It should be nose or tail loaded and have the capacity for at least 13 of the 6.1m (20ft) intermodal containers or their equivalent on the main cargo deck. Some modifications of existing craft, e.g., the B-747-200F or 747-11/111F, meet these requirements.
2. A new midrange dedicated cargo plane should be developed for domestic use. Normal stage lengths for it would be between 1600 and 2260km (1000 to 1400mi). It should be nose or tail loaded and have the capacity for 4 of the 6.1m containers or their equivalent. This would be a payload capacity of 40tonnes (80 000lb).
3. New aircraft should be designed to carry 2.44 x 2.59 x 6.1m containers as well as 2.44 x 2.44 x 6.1m ones.
4. The midrange aircraft should be quiet enough to conform to noise limitations for night operations. It should be fuel efficient, using composites and new engines.

Recommendations concerning the domestic air cargo network:

1. An advanced air cargo system should have a hub and spoke network augmented by point-to-point service between high traffic city pairs.
2. Three types of airports should be integrated into the hub and spoke networks: major hubs, minor hubs, and local (feeder) ones.
3. The LCA should fly only between major hubs and high traffic pairs. The intermediate range craft is appropriate to service all three types of airports.
4. At least three major hubs should comprise the axis of this system in the United States. These would function as gateways for trade moving to or originating from Asia, Europe, and Latin America. The ports of San Francisco, New York, and Houston have been used for reference within this report, however, these specific sites are merely exemplary. Other sites in these regions may be more appropriate.

5. Considerable operating line-haul cost reductions in cargo networks accrue from "dynamic scheduling", that is, routines which are flexible based on load factors and day to day variations in cargo at planned ports of call. It is recommended that this technique be explored for applications to large package freighter operations.
6. Network, schedule, ground operations, and aircraft design should be simultaneous. The economics of all these elements are interdependent.

Recommendations concerning ground support:

1. The proportion of small package traffic handled by certificated freight forwarders should be increased.
2. Individual airline companies should not develop off-airport cargo handling facilities or gate-arrival terminals. If these configurations are used, union terminals, i.e., facilities held in common by all freight carriers at a port, must be implemented.
3. New terminals must have a capability of handling at least the 6.1m intermodal containers. At major hub terminals, this should include the use of fixed conveyors for direct nose or tail landing. Containers with limited intermodality, i.e., the M-2, should not be the axis around which terminal operations are built.
4. Major international hubs should include spurs to access COFC rail shipments.
5. Airport design concepts should minimize problems in interfacing transshipment between all freight flights and transferability between belly cargo moving on passenger flights with that on all freight flights.
6. All terminal operations systems should be automated to optimal economic levels.
7. Computerized systems for routing of movements and documentation on them should be integral to the system.
8. Containers of reduced tare weight should be developed using composite materials and placed in the system as they are economically feasible.
9. A computerized reservation system would enable air freight carriers to dynamically schedule aircraft and independent commission agents to communicate the kind and type of freight service that is available (unreserved) and at what cost.

Recommendations concerning regulation:

1. The area served by air freight forwarders should be extended to a radius of at least 100 miles.

2. Regulation of air freight should not include tariff and route approval for the ACIS, unless the current policy in that direction proves unsuccessful. New tariffs should still be filed with the CAB, but substantial notice should not be required.
3. Airlines should be permitted to own common carriage interstate trucking subsidiaries or divisions. Joint ownership or other combinations of firms in transportation modes should be permitted, except as specific anti-trust violations occur.
4. A single agency should regulate all transportation. Its divisions should be functional. One division would do all economic regulations; separate divisions would oversee safety and other areas.
5. International agreements concerning landing rights should allow aircraft with authorization to land, to discharge, and take on any available cargo, and to carry cargo on any leg of their flight.
6. International negotiations concerning landing rights and other air operations should recognize the importance of door-to-door service, rapid delivery, and intermodal operations.
7. Bill of lading provisions should be sufficiently uniform between modes to allow a single bill of lading to serve for shipments traveling on journeys of several legs, even if the journey involves several modes and/or several carriers.
8. Minimum insurance provisions, carrier liability provisions, and availability of additional insurance should be uniform between modes. Where a shipment travels via several modes or carriers, liability should be uniformly defined so that the shipper or consignee knows who is responsible.
9. The ability of the national transportation network (as a whole) to carry live animals, hazardous substances, etc., should be preserved or enlarged. In this case, of course, a unified agency could relieve one class of carriers from carrying, say, live animals, on a given route if carriage by another mode was preferable and available.
10. There should be independent commission agents, comparable to travel agents, able to arrange and prepare bills of lading for travel of freight whether on single or multi-stage journeys, involving single or multiple modes or carriers.

Recommendations concerning public policy:

1. The United States Government should continue to support research and development of large cargo aircraft. An increased effort in the area of freighters using alternative fuels is likely to produce useful long term returns and may be important to the 1990-2015 time period.

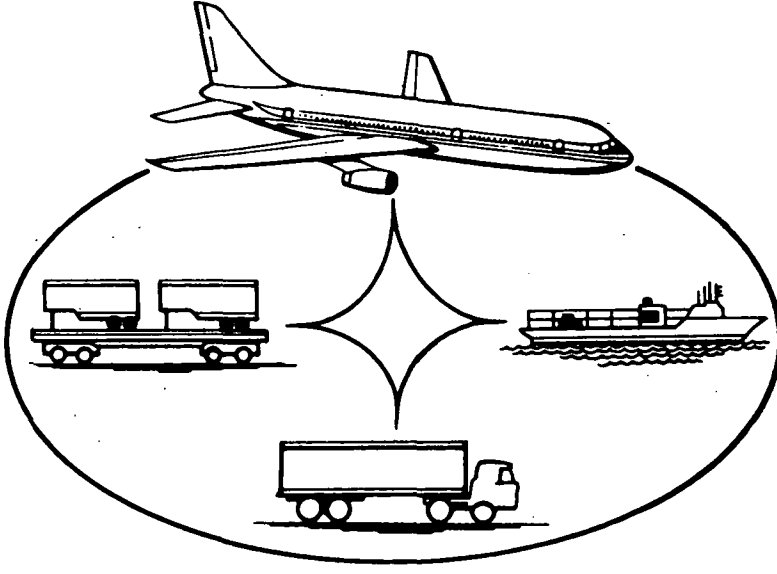
2. Uncertainty over the type and amount of fuel available confounds planning of air transportation systems. Clear allocations of fuel should be made as a matter of national policy to facilitate and prioritize design efforts.
3. Any government subsidy of large cargo aircraft should be for their construction, promotion, and to facilitate their purchase, i.e. providing favorable loans or loan guarantees to buyers. They should not subsidize operations.
4. The military should maintain a fleet of large cargo aircraft sufficient to meet their needs for movement of outsized cargo and wheeled vehicles. The major capacity for airlift of more routine commodities should be in the CRAF fleet which is optimized to civilian needs.
5. International consortia possibly among NATO allies, for the development and manufacture of both civilian and military large cargo aircraft should be considered. Specific feasibility studies in this area would be useful.
6. Customs procedures should be simplified; international agreements to forward this goal should be sought.
7. United States dependence on foreign resources should be controlled by 1) encouraging the conservation of minerals; 2) increasing domestic technological innovation; and 3) increasing the standby potential by stockpiling resources with limited domestic reserves.

Recommendations concerning future research and air cargo data development:

1. Past and current automated techniques should be cataloged and analyzed in order to identify successful and unsuccessful operations. The tendency to assign all functions to machines, even where the human operator is more efficient, must be avoided. Long-term reliability and versatility may be more important than short-term handling capacity.
2. Statistics and rankings of airports for cargo should be based on the larger of the enplaned or deplaned cargo moved. This is a more equitable base across airports since, unlike passenger traffic, cargo flows are often strongly unbalanced. This base would retain the peak handling nature of the airport's cargo operation, though total volume would still determine the ranking for revenue purposes.
3. An organized gathering of information on existing civilian and selected military airports should be undertaken so that rational decisions can be made on expansion potential in accommodating the larger freightports, consolidation facilities needed for hub and feeder portions of the system, and for locating new intermodal nodes in which air cargo may or may not be the initiating force.

4. Considerable effort should be devoted to studying means of making airports more attractive to potential nearby residents. It would be highly desirable to have some studies addressing this question as a long-term, abstract problem, rather than in fashions strictly limited by location or time frame. For instance, changes in property tax practices not practical under present law might be a useful tool.
5. Research activity should be directed toward the development of quiet, fuel efficient engines for new craft that can be retrofitted into existing large mainframe cargo aircraft.
6. Research on composite materials and any other innovations to lighten the weight of craft is critical to the intermodality of cargo aircraft and should be emphasized.
7. Research on alternative fuels and freighter configurations employing them should be continued. Public acceptance of hydrogen powered cargo planes might be easier to achieve than passenger craft.
8. The role of the crane helicopter, on a limited scale and over short distances, should be seriously considered. This craft must be able to lift standard intermodal containers.
9. Research on the volume vs. weight capacities of aircraft is critical to future aircraft design. Intermodality of the ACIS may depend on designs which emphasize increased lift rather than more cubic space.

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APPENDICES

APPENDIX A ORGANIZATION AND METHODOLOGY

The systems design group first organized to set objectives for its summer work. For this task the overall group of 20 was broken into four, five member teams. Each team was designed to be as interdisciplinary as possible. Members were assigned as follows: (the asterisk indicates the team chief)

Team #1

R. J. Burns
A. H. Hagedoorn*
N. Matthews
M. K. Mohapatra
W. A. Rabiega

Team #2

R. M. Eastman
A. Hargrove
E. Maier
F. E. Rogers
J. T. Ying*

Team #3

M. L. Cross
E. E. Enscoe
P. K. Grogger
E. T. Ordman*
E. A. Thomchick

Team #4

J. B. Crittenden
A. E. Keaton
S. T. Koay
R. A. Olsen*
M. T. Soberick

On June 16, 1978, after two weeks work the four teams met together and settled on overall objectives. This meeting was conducted for a period lasting approximately 12 hours distributed over a Friday and a Monday. The meeting began with each team presenting its proposal for objectives. The four presentations were followed by a discussion. While considerable commonality was discovered in the various teams' presentations, clear differences of opinion also emerged. In an attempt to reconcile these differences the large group was broken into smaller discussion groups. The assignments of individuals was made in such a way that principal antagonists on major points were placed in the same discussion group. This was done because we hoped that compromise could be reached more effectively in the small group environment. Towards the end of the second day of the meeting objectives could be stated by the groups with a satisfying degree of consensus.

After the initial phase culminated in a statement of objectives, the group was organized in such a way that the tasks pursuant to the stated objectives could be accomplished. This led to the following task organization.

Network Design Team

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S. T. Koay
E. Maier*
R. A. Olsen

Ground Support Subsystem Team

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E. E. Ensore
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Regulatory Issues Team

M. L. Cross
E. T. Ordman*
F. E. Rogers
M. T. Soberick
E. A. Thomchick

Public Policy Team

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A. E. Keaton
M. K. Mohapatra*
J. T. Ying

Societal Impacts Issues Team

R. J. Burns
E. E. Ensore
P. K. Grogger*
A. E. Keaton
E. A. Thomchick

Economic Team

J. B. Crittenden
E. E. Ensore
E. T. Ordman
J. T. Ying*

* denotes team leader

The first four of these teams made up the basic task structure. The last two were formed to satisfy a strongly felt need to integrate the consideration of impacts and economics into the full systems design effort. Notice the organization of these provides for liaison between task teams through commonality of membership. This method of providing for organizational "intersection" is graphically illustrated in figure 1. This task organization was maintained until the end of the program. A team was also found for the purpose of making an oral presentation of results. The members of this team were:

Presentation Team

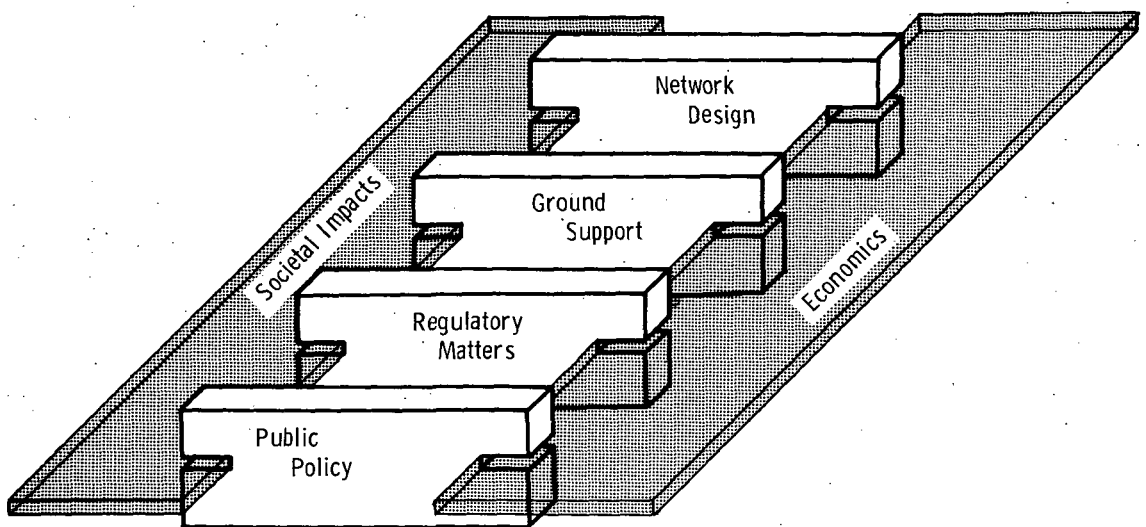
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P. K. Grogger
A. H. Hagedoorn
M. K. Mohapatra

A number of systems design group decision-making methodologies were employed throughout the program. Notable among these were the use of interpretive structural modeling in an interactive computer mode and delphi exercises.

The interpretive structural modeling was used with the group of task team leaders to produce the objective structure discussed in the introduction. The computer software was produced at and purchased from the University of Dayton. The team leaders spent approximately 12 hours initially interacting with the computer to structure a list of 56 objectives which had been suggested by the program participants. By individual and small group effort this structure was reduced to the one presented in the introduction. The exercise proved valuable in forcing discussion of terms and concepts which led to a clarification of the issues.

Delphi exercises were used twice. The first use resulted in the evolution of the set of assumptions listed in the introduction. This was done by first forming a long "grocery list" of assumptions (66 in all) and then by asking for judgements on the acceptability of each (and some editing based on feedback) eventually determining the ten most acceptable ones.

The second delphi exercise was conducted in order to achieve a best estimate on the time in which our air cargo system would be in place. The results are clearly indicated in the text.



Task Organization

APPENDIX B
FACULTY FELLOWS AND ASSOCIATES

NASA-ASEE ENGINEERING SYSTEMS DESIGN PROGRAM
SUMMER 1978

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APPENDIX C SPEAKERS

<u>Date</u>	<u>Speaker/Affiliation/Topic</u>
June 8	Bill Kuhlman Douglas Aircraft Company "NASA-CLASS (Cargo/Logistics Airlift Systems Study)"
June 9	J. M. Norman Lockheed-Georgia Company "NASA-CLASS (Cargo/Logistics Airlift Systems Study)"
June 12	Bob Kulthau University of Virginia, Charlottesville, Virginia "Small Community Air Freight Service"
June 13	Col. Floyd D. Castleman Military Airlift Command, Scott Air Force Base, Illinois "Potential for Civil/Military Airlift Commonality"
June 14	Allen Whitehead NASA-Langley Research Center "Guidelines for the Systems Design of the Air Cargo System"
June 15	Nawal K. Taneja Massachusetts Institute of Technology, Cambridge, Massachusetts "Air Freight Demand Modeling"
June 22	Alvin F. Anderson NASA-Langley Research Center "NASA/University Contract Relations"
June 23	Oscar Garcia NASA-Langley Research Center "NSF-Research Grants and University Affairs"
June 27	Frank Driscoll McGaughy, Marshall, & McMillan "The Design of a Modern Air Cargo Terminal"

June 27	Steve Feinman Gellman Research Associates "Technology Impact Assessment of Large Cargo Aircraft"
July 6	William Duffy DOT-Transportation Systems Center "Characteristics of 1990 Demand for Freight Transportation and Modal Comparisons"
July 7	Ernie Stern Civil Aeronautics Board "Government Regulation"
July 11	John N. Warfield University of Virginia, Charlottesville, Virginia "Large-Scale Systems Design"
July 14	Lynn E. Jackson Federal Aviation Administration "Air Freight Future"
July 19	Dennis K. Tsai Federal Express Corporation "Planning at Federal Express"

APPENDIX D

GLOSSARY OF ACRONYMS

ACIS - Air Cargo Integrated System
AFC - Air Freight Carrier
ANSI - American National Standards Institute
ATA - Air Transport Association
CAB - Civil Aeronautics Board
CCS - Customer Communications Service
CNR - Composite Noise Rating
COFC - Container On Flat Car
COGSA - Carriage Of Goods By Sea Act
CSR - Customer Service Representative
DAFRI - Domestic Air Freight Rate Investigation
DOT - Department Of Transportation
EPA - Environmental Protection Agency
ETA - Estimated Time of Arrival
FAA - Federal Aviation Administration
FAR 36 - Federal Aviation Regulation, part 36
FMC - Federal Maritime Commission
IATA - International Air Transport Association
ICAO - International Civil Aviation Organization
ICC - Interstate Commerce Commission
ISO - International Organization for Standardization
LCL - Less than Carload Lot
NEF - Noise Exposure Forecast
NRR - Non-Renewable Resource
OPEC - Organization of Petroleum Exporting Countries
RO-RO - Roll On - Roll Off
RTM - Revenue Ton-Mile
SAE - Society of Automotive Engineers
TOFC - Trailer On Flat Car

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APPENDIX E
SELECTED BIBLIOGRAPHY

The members of the Design Team found the materials listed below useful as sources of background knowledge for the study. These are in addition to the references cited at the end of each chapter.

- Abouchar, Alan: Transportation Economics and Public Policy: With Urban Extensions. John Wiley & Sons, Inc., 1977.
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APPENDIX F
RESOURCE PERSONS

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